Agriculture Innovation : A way forward for Nation Development

Editors

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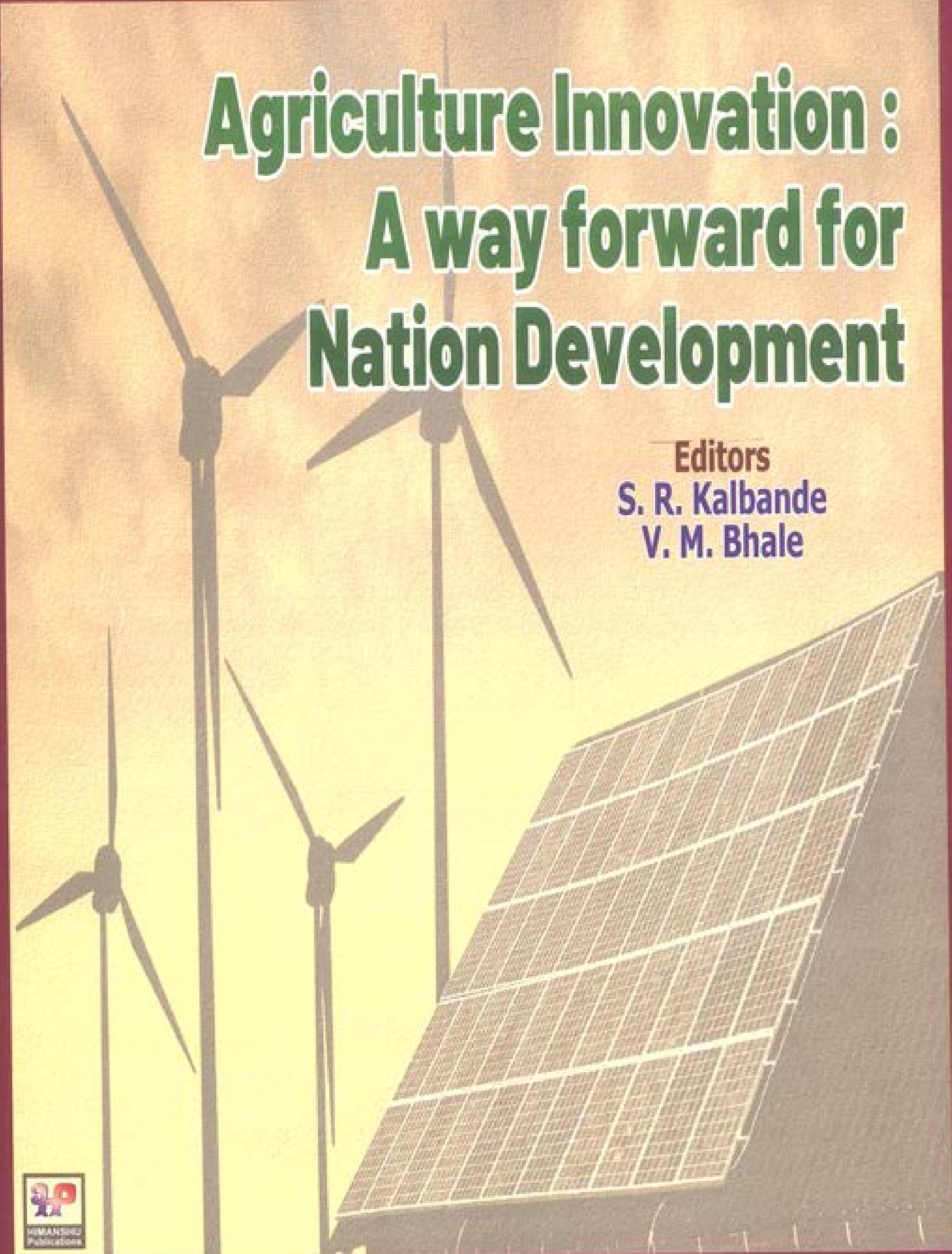

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National Higher Education Project

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National e Conference on
Agriculture Education, Innovation and Research
for Future Livelihood - Indian Scenario in 2050

January 28-29, 2021

Department of Unconventional Energy Sources and Electrical Engineering
Faculty of Agricultural Engineering
Dr. Panjabrao Dehmukh Krishi Vidyapeeth,Akola
Maharashtra State, India 444104

Himanshu Publications

Udaipur - New Delhi

The authors of the papers are alone responsible for technical contents of the papers and references therein.

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4379/4-B, Prakash House, Ansari Road, Daryaganj, New Delhi - 2; Phone : +91-96109-73739
e-mail : *himanshupublications@gmail.com*; web: *www.himanshupublications.com*

ISBN : 978-81-7906-934-9

Edition : 2021

Distributor

ARYAS PUBLISHERS DISTRIBUTORS (P) LTD.

2-D, Hazareshwar Colony, Near Court Choraha, Udaipur (Raj.) - 313 001; Phone : 0294-2526160
E-mail : apdpl.2012@gmail.com

Preface

Maharashtra state has its own beauty and unique system of agriculture. The people of the region are mostly dependent on agriculture and allied activities for their livelihood. The pace of the advance agriculture has increased due to adoption of innovative technologies in agriculture and allied subject for proper and efficient utilization of the existing resources.

Increasing demands of food for world population have become a challenge for all the stakeholders. Agricultural scientists and researchers need to develop efficient eco-friendly and sustainable agricultural technologies. The twin agrarian challenges of retaining youth in farming and ensuring profitability can be ensured by capacity building, enhancing skill and empowering the farmers with innovative farming system and farm technologies. Sustainable agriculture polices can help to transform conventional agriculture towards a more environmentally, economically and socially endorse future of farmers. Thus, there is a need for innovations and opportunities in agricultural education by developing education resources that will attract the very brightest of students to select there a career in an agriculture, development of strategies to improve dissemination of research outcomes to the farming sector and innovations in the education of the general public. Considering the above aspects, the national e-conference on **"Agriculture Education, Innovation and Research for Future Livelihood - Indian Scenario In 2050"** was organized by NAHEP (IG), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with the support of ICAR, New Delhi during January 28-29, 2021.

This handbook is manuscript souvenir of the conference which has been prepared to provide up to date information and research material to the university teachers, researchers and extension workers. It contains chapters from expert scientists and research scholars having sound knowledge of advance technologies of agricultural interventions. The latest information in this book will definitely prove a valuable source of information which will help the hands-on experimentation to the field scientists, teachers and the students in particular.

S. R. Kalbande
V. M. Bhale

About the Editors

Dr. S. R. Kalbande is presently working as Professor and Head of Department of Unconventional Energy Sources & Electrical Engineering and Registrar, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. He did his M.E. in Renewable Energy Sources from CTAE, Rajasthan Agricultural University, Bikaner and Doctorate from Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra). He has contributed more than 100 scientific papers and 8 books on various aspects of Renewable Energy and Agricultural Engineering. He has organized 32 national and international level seminars/workshops/winter schools / short courses and training programs. He is the recipient of ISAE Distinguish Service Award-2015, ICAR Best Teacher Award – 2015, Achievers Award 2016 of Society of Advancement of Human and Nature, Dr Y.S. Parmar University of Horticulture, Salon, Eminent Engineer Award 2017 of Institution of Engineers, India of Amravati local centre, Received many Best paper/Poster presentation awards for the various organization.

Dr. V. M. Bhale is the Vice-Chancellor of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. He did M.Sc. with specialization in Agronomy from Marathwada Agriculture University, Parbhani and Ph. D. (Agronomy) from University of Agricultural Sciences, Bangalore. He is a Fellow of 'Indian Society of Agronomy' and recipient of Dr. Abdul Kalam Lifetime Achievement National Award-2014. He is presently working as a 'Vice President' of Indian Society of Agronomy. He has contributed more than 118 scientific papers, 7 Books, 32 radio and TV talk and 47 extension publications on various aspects of agricultural science. He has undertaken 11 research projects and organized International trainings, seminars, workshops and conferences. He has guided 12 Ph. D. and 31 M. Sc. Student and recommended various useful technologies for improving crop yield. He was recently honoured by Marathwada Bhushan Award-2014. He is recipient of Krishi Gourav Puraskar, 2018. Recipient of "Gold Medal" from Indian Society of Agronomy for contribution in developing Organic Farming on October 24, 2018.

About the Book

This handbook is manuscript souvenir of Two Days National e-Conference on "Agricultural Education, Innovation and Research for Future Livelihood-Indian Scenario in 2050" conducted by National Agricultural Higher Education Project (Innovation Grant), Faculty of Agril. Engineering, Dr. PDKV, Akola during January 28-29, 2021. This handbook is useful to the students and faculties of agriculture and allied sciences, scientist, extension faculties of State Agricultural Universities and ICAR Research Directorate. It contains various topics contributed by experts and research scholars belonging to diverse field of agriculture and allied sciences. This handbook highlights recent advancement in agricultural education and research and innovation. The edited chapters provide practical guidance and are beneficial to new learners.

Content

Theme I

Agricultural Education

Effect of New Education Policy on Agriculture Education in India

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Abstract: Agriculture sector is the back-bone of Indian economy. Agriculture and its allied sectors still remain an important sector because of its continued role in employment, income and most importantly in national food security. Food shortage is faced by our country at the time of independence and due to green revolution, we became self-sufficient in food grain production despite of increased population. Due to the wake of COVID-19 situation, the problems in agriculture education, research and development are increased. Apart from this condition, farmer's income has to be doubled, also the new policy of Indian government by increasing the agricultural productivity and giving minimum support price for the produce. So, it is necessary to boost the agricultural research and education for achieving the goals. This paper describes the effect of new education policy and COVID-19 pandemic on position of current agriculture education, research and development.

Keywords: Agricultural research, Agricultural Education, State Agricultural University, Indian Council of Agricultural Research

Introduction

Nowadays, there are 67 AUs set up on the Land Grants pattern of the USA which involves financial contributions from the State and Centre, as well as resource generation by the university. Although AUs comprise approximately 9% of all universities in the country, enrolment in agriculture and allied sciences is less than 1% of all enrolment in higher education. There is high demand in the government and development sector for agriculture graduates and there is also increasing demand in the private sector in all aspects of agriculture, particularly high-value agro-industry, food processing and specialised knowledge-intensive areas such as water efficiency, food safety and trade. Both general and specialised education in agriculture is needed, in order to increase agricultural productivity through better skilled graduates and technicians, innovative research and market-based extension linked to technologies and practices. In India the agriculture sector is passing through a dynamic phase in the recent era of development. This sector provides 65% of employment opportunities for the working population of India. Since post-independence period, the Government of India has been initiating its policy framework for the structural, technological and institutional changes for agriculture. The special address was for the agriculture sector to deal with the food crisis during 1st five-year plan (1951-56). Since then there is found continuous decline in the composition of GDP from the agriculture and allied activities. With the concern of agricultural crisis and lower productivity, the 11th five-year plan (2007-08 to 2011-12) made a target to reverse the deceleration in agriculture growth and productivity. In 12th five year plan the main focus is for the rapid and inclusive growth of the agriculture. The world economy has been witnessing the slow growth rate since 2008-09 which has resulted in sluggish growth in all the sectors of India. Although the farm productivity is low as compared to other developed countries, some improvements have been found due to certain developmental activities. These include, technological advancement, adoption of (High yielding Varieties) HYVs of seeds, usage of improved quality of fertilizers, insecticides, pesticides, new cropping pattern, new irrigation facilities, farm research and management practices. Agricultural Education in India is strengthened and streamlined centrally by the Indian Council of Agricultural Research (ICAR) and is imparted through State Agricultural Universities (63), Deemed to be Universities (4), Central Agricultural Universities (3), Central Universities with Agriculture Faculty (4) and a few other institutions under private and public sectors. Altogether there are about 35,000 Faculty Re-imagining Higher Agricultural Education in India on the Face of Challenges from COVID-19 Pandemic members spread across these Universities who are engaged fulltime in teaching, research and extension pertaining to agricultural and allied sciences, and an estimated 1.65 lakh students are pursuing various Undergraduate, Postgraduate and Doctoral programmes in these institutions (2019-20; https://education.icar.gov.in/).

Literature Review and Analysis

Kulshrestha, A.K and Pandey K. (2013), It is a process of building up personality and making him or her rational, capable, receptive and intelligent. Education is the ability to meet life's situation. Twenty-first centuries is marked by a multiculturalism that has emerged as a result of industrialisation, urbanization, globalization and family disintegration. The century of stress and stress is described. Education should prepare the youngest generation to understand and face the realities of globalization, because it is seen as a tool to develop cognitive qualities, tolerance and understanding of people.

Singh, L (2013), In terms of context and the person in question, globalization has many meanings. Globalization refers to integration of the world economy by uninhibited trade and financial flows, as well as by mutual technology and know - how exchanges.

Singh T. S. (2012), Education is just as old as mankind. It is an endless process of internal development and development extends from the cradle to the grave. Education really means humanizing humanity and making life advancing, cultivated and civilized. For the development of the individual and society, it is extremely important. By education people develop their thinking and reasoning, problem-solving and creativity, intelligence and ability, positive feelings and abilities as well as good values and attitudes. The person is well balanced by education, aesthetically rich, culturally sound, emotionally stable, mentally alert, morally upright, physically strong and healthy, socially efficient, vocationally self-evident, and internationally liberal. Education is the whole of life, as the ever-growing man and society is a constant and dynamic process.

Impact of the Pandemic on Agricultural Education in India

COVID-19 has caused unusual disorder to various sectors of economic development and education sector. The lockdown by the Union and State Governments to improve the impacts of the pandemic has surprise the entire academic board. While the Traditional Educational Institutions in India have mostly remained closed and had closed their activities, the State and Central Agricultural Education Institutes, including the Deemed Universities under ICAR have relatively responded positively, despite of their basic limitations, which could be attributed to the sustained efforts of the Indian Council of Agricultural Research in coordinating national exercises for building digital content in partnership with all members of the National Agricultural Research and Education System (NARES) and building the skill sets of the Faculty Members in using digital technology for teaching. A study was designed to find out the consequences of COVID-19 during the lockdown period, response strategies adopted and lessons learnt for future. Data were collected during April, 2020 on a structured survey schedule administered as an online survey using Google Forms, pointing the students and Faculty Members spread across India. In all, 1132 students from 51 Agricultural Universities undergoing Ph.D. (14.9%), Masters (5.8%) and Undergraduate (79.2%) courses and 164 Officials from 61 Universities comprising of Administrators/ University Officers (31.7%) and Teaching Faculty (68.3%) had participated in the survey. About 84.0 % of faculty and administrators expressed that their Universities were able to handle the impacts created by COVID-19 and about 71.8 % expressed that they had facilities for imparting digital education. A significant proportion of the respondents (41.7 %) opined that the access to online educational resources (OERs) was moderate / average, while 18.4 % responded that the access was very good. Quality of learning materials was another area of major concern, with 46% of the respondents expressing that the digital literature accessible to them are of moderate / average quality. The broad impacts of COVID-19 on agricultural education as perceived by the University Officers (taking care of administration) / Faculty Members (engaged in teaching) and the students based on the survey are presented briefly under three broad heads viz., (i) course delivery, (ii) building professional competence, and (iii) physical and psychological health.

1.1 Impact on Course Delivery

(a) **Loss of time:** 35 to 45 calendar days out of 50 days were loss in lockdown, depending on respective State Government decisions at the end of lockdown 2.0 (3-5-2020). The effective academic learning time and effective faculty time (includes time for other activities apart from actual teaching such as preparation, evaluation of records, answer scripts, assignments, etc.) were loss, ranged from 210 to 270 hours per student and 235 to 300 hours per Faculty Member across the Agricultural Universities in India. The States with larger number of students and Faculty members had major extent of loss.

(b) **Academic activities disruption**: All higher Agricultural Education Institutions were closed physically, however a few Universities started the programmes and online engagements, disruption of academic calendar and activities were result of the lockdown. The universities and other tertiary education institutions were closed in 175 countries and communities, and over 220 million post-secondary students equal to 13% of the total number of students affected globally due to COVID-19, as on April 8, 2020 (The World Bank Group, 2020).

(c) **Problem of experiential learning:** Unlike traditional degree programmes, courses of agricultural and allied sciences have built-in practical components (around 30%) and experiential learning modules through field experiments and village visits. The lockdown disappears these learning experiences. The online engagements of the Faculty Members partially contributed to the knowledge component, but the lockdown had severely impacted the skill component.

(d) **Problem of career progression schedule:** This issue was important among the students in the final year of their under-graduation and post-graduation in terms of planning their next logical career progression i.e., taking up higher studies, preparing for competitive exams or taking up employment in private or public sector. The uncertainty was particularly more pronounced among those who aspired to go for a suitable placement, in both private and public sector, following the huge impact of the COVID-19 on the economy.

(e) **Social learning restrictions**: Apart from clear instructions, learning also happens among students due to their engagement in practical classes or project based assignments. The courses of agriculture and allied sciences have a unique design in which all undergraduate and post graduate students, particularly those in social science area, are engaged in the social learning process. They would get to learn through observation of people's behaviours, and also learn from each other under and from wider social-ecological systems. Lack of access to these social contexts inbuilt in the Agricultural Education Institutions during the lockdown, compromised the opportunities to students from acquiring these experiences

1.2 Impact on Building Professional Competencies

(a) **Issues related to gaining knowledge**: Depending on their year of standing, the courses for a undergraduate programme in agriculture and allied sciences are well-structured with about 18 to 24 credits of theory and practical classes, per semester. The students could not have as much knowledge gain as under normal circumstances, due to the loss of significant instructional time. On other hand the significant efforts taken by the Universities to establish online teaching programmes scheduled during most part of the lockdown.

(b) **Issues in skill acquisition**: Most of the agricultural courses have a significant practical component (about one-third) in the course structure, which contributes towards skill up gradation. The course structure also provides for experiential learning, project-based learning and activity-based learning through equal interaction. This component was the most affected one due to the lockdown impact with the closure of all Institutions/ Universities and many times imparting skills through online is a challenge.

(c) **Inadequate access to faculty mentoring / counselling:** A unique structure for enabling personalized mentorship for the students, all the Agricultural Universities have instituting course coordinators, student advisors and few councillors for each batch of the students across the graduation levels. The benefits to the students through interaction with their coordinators, advisors, councillors who otherwise constantly stay engaged with the curricular and co-curricular activities of the respective batches, were marginally affected due to displacement of students, while some of the respondents opined that they could still stay engaged with them in these difficult times when the students have low morale.

1.3 Impact on Physical and Psychological Status

(a) **General health:** As the lockdown largely restricted the mobility of the people, the perception of students on their physical health viz. body weight, blood pressure, physical activity, nutrition & diet, and rest and sleep were studied. The respondents comprising of students of Undergraduate, Post graduate and Doctoral degrees, in the age group of 17 to 27 years opined that lockdown had a significant restriction on physical activity (25%) and improved rest and sleep (26%), while they did not perceive any change in their body weight (34%), blood pressure (61%), and nutrition and diet (24%) due to lockdown.

(b) **Psychological health**: In this study, the students perceived a significant impact of lockdown on their psychological health. The lockdown adversely affected their self-confidence (29%) and overall attitude (23%), caused boredom (46%), frustration (36%), anxiety (32%), depression (29%), uncertainty (30%) and desire for isolating (25%), and ultimately led to loss of collective/group behaviour (38%). The perceptions on the adverse impacts of lockdown varied significantly.

Conclusion

A time to time improvement in the education system is essential for human development and sustainable progress in society. Changes in the education system by considering various success models in developed countries and customizing such things with local needs is the present requirement for a country to bloom. India, being a fast developing country with 130 crores human capital can progress and overtake other developing countries by planning and adopting an appropriate education model. In this aspect, the present National Education Policy proposal 2019 is an inclusive model with many innovations to provide liberal but specialized and customized both school and college education by incorporating research components both at school and college levels. Concerted efforts would be required to transform Indian agricultural education system to make it more sensitive and responsive to the need of stakeholders. ICAR is making concerted efforts to improve the agricultural education.

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Agricultural Education, Innovation and Research for Future Livelihood-Indian Scenario in 2050

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Abstract: The main purpose of this paper is to introduce the agricultural education innovation in modern technology, and research for future livelihood. In the last century, the basic agriculture technology like machines has changed a little. Though the modern technology, planters and harvesters do a better job or are slightly tweaked from their predecessors. Technology Assessment (TA) is an applied process that considers the societal implications of technological change in order to influence policy to improve technology governance. However, the modern technology is changing the way that humans operate the machines, GPS locators, as computer monitoring systems and self-steer programs allow the most advanced tractors and implements to be more precise and less wasteful in the use of fuel, fertilizer or seed. In future, there may be mass production of driverless tractors and other agriculture machinery which use electronic sensors and GPS maps.

Keywords: Agricultural education, Innovation, Adoption, Tractor, GPS, Crop sensor

Introduction

Education is the ability to meet life's situation, it is a character-building process, enhancing one's personality and making him/her rational, capable, responsive and intelligent. Twenty first century is characterized by the emergence of multiculturalism due to industrialization, urbanization, globalization and disintegration in the family system. It is described as the century of stress and strain. Since, education is viewed as an instrument to develop the cognitive qualities, tolerance and understanding of people, it should prepare the younger generation to understand and face the realities of globalization (Kulshrestha, A.K and Pandey, K. 2013).

Education is as old as the human race. It is a never-ending process of inner growth and development and its period stretchers from the cradle to the grave. Education, in real sense, is to humanize humanity, and to make life progressive, cultured, and civilized. It is very important for the progress of Individual and society. It is through Education that man develops his thinking and reasoning, problem solving and creativity, intelligence and aptitude, positive sentiments and skills and good values and attitudes. It is through Education that the Individual is become a well-balanced personality, aesthetically rich, culturally sound, emotionally stable, mentally alert, morally upright, physically strong and healthy, socially efficient, spiritually enlightened, vocationally self-sufficient and internationally liberal. The entire life is Education as it is continuous and dynamic process forever growing man and society (Singh, T.S.2012).

India has come a long way from the situation "living from ship to mouth" to "food self-sufficiency". On a world-wide basis, India today has 17% population, 11% livestock, 4.2% water, and 2.4% area. The country has 142 million ha cultivated and 60 million ha net irrigated area with 138% cropping intensity; 58% of population earn livelihood in agriculture. The agricultural sector contributes 14.5% to gross domestic product (GDP) (Ayyappan, 2012).

Varying agro-climatic zones and a variety of soil conditions have facilitated the cultivation of almost all the cash crops and food grains. In recent decades, India has significantly improved the well-being of its people. With over half a century of development, agricultural education and research have been instrumental in a Green Revolution in the country. However, poverty remains India's most compelling challenge (Reddy, 2009). India will be facing serious challenges to achieve a target growth rate of 4% to reduce poverty at a fast rate. Moreover, the agricultural sector is getting more complex due to globalization, impact of climate change, entry of corporate sector in agricultural value-chain, diversification of agriculture towards high value commodities, expanding demand for processed food, and need for post-harvest technology. To address these challenges, India will need rich human capital of highly qualified, motivated, and well-trained agricultural scientists (Desai *et al.*, 2009).

In order to sustain, diversify and realize the potential of agriculture sectors, it is necessary to develop skilled human resources. Agricultural human resource development is a continuous process undertaken by agricultural universities. Agricultural universities impart education in the various disciplines of agriculture viz., Agriculture, Agricultural Engineering, Forestry, Horticulture, Veterinary and Animal Husbandry, Dairy Science, Food Technology, Fisheries Science, Agriculture Information Technology, Agricultural Business Management etc. It imparts education at the level of diploma, degree, masters and doctoral level.

- **Agricultural Education: Pre-Independence Era**

At the time of Independence, India faced food grain shortage. India achieved spectacular growth in agriculture sector since 1966. India today is self-sufficient in most of the food grain despite population increase. The history of agricultural education in India can be traced back to medieval period when study of agriculture was included in the curricula of Nalanda and Takshashila Universities as an important subject. However, formalised courses in agricultural education began only at the beginning of 20th Century when six agricultural colleges were established at Kanpur, Lyalpur (now in Pakistan), Coimbatore and Nagpur in 1905, at Pune in 1907 and at Sabour in 1908 under the General Universities.

Realizing the need for increased food production, the Government of India decided to assist the development of agricultural research and demonstration. The Imperial Research Institute was established in Pusa in the province of Behar in 1905; it was later transferred to New Delhi and now functions as the Indian Agricultural Research Institute, a premier institute for teaching and research. A major development took place with the creation of the Imperial Council of Agricultural Research in 1929, an apex central body to promote and coordinate agricultural research at state and national levels. After India gained independence in 1947, the Council's name was changed to its present name, the Indian Council of Agricultural Research (Reddy, 2009).

- **Agricultural Education: Post-Independence Era**

After Independence, the Indian University Education Commission was appointed and was headed by Dr S Radhakrishnan. In its report submitted in 1949, the commission urged that the country needed a continuous flow of scientific workers as well as leaders in all fields including agriculture. It was in 1954 that the first Indo-American joint team was appointed; in 1955 the first authorization was provided for five universities contracts with United States Agency for International Development (USAID) to strengthen agricultural universities in India. The first Agriculture University in the country was set up in 1960 at Pantnagar (now in Uttarakhand), which paved the way for establishment of agricultural universities in other states. At present, there are 73 Agricultural Universities (AUs) including five deemed-to-be universities, two Central Agricultural Universities and four Central Universities with agriculture faculty. The intake capacity of students, which was less than 5,000 in 1960, has now gone up to 40,000. With about 350 constituent colleges, these AUs enrol, on annual basis, about 25,000 students at UG level, over 15,000 at Masters' level and Ph.D. programmes. In addition to this, there are many private affiliated colleges enrolling thousands of students annually. There are about 23,000 scientists for teaching, research and extension under the present ICAR-Agricultural Universities (AUs) system. Degree courses in 11 UG disciplines and 93 disciplines at PG level are offered with an emphasis on learning through hands on practice sessions. About 52% students admitted are from rural background and 36% are girls.

- **Innovation Technology for Agriculture**

Innovation, which broadly refers to the use of new ideas to improve ways of doing things, is relevant at the policy level in two primary ways. First, there are new ideas about regulation and governance that can be taken up. The policy level is no different to any other level in the value chain in that invention and discovery about how to do things better does occur, and in that these new ways should be implemented. Secondly, the overarching policy framework may have a profound effect on innovation at points lower down the value chain. Policy can encourage and facilitate the adoption of new ideas and practices, and it can also impede adoption and innovation (Carruthers and Vanclay, 2012).

Innovative technology has changed the face of agriculture throughout the world. From social networks to cutting-edge tech like self-driving vehicles, farming is going digital. Thereby, giving stakeholders a lot of innovative solutions for effective farming. More focus has been placed by governmental and international bodies to achieve sustainability in agriculture. Creating more sustainable farming practices requires adopting new technologies for crop management, pest control, quality control, and integrated disease management. The new technologies allow current and future generations of farmers to grow without compromising the needs of the earth. Modern technology and machinery in agricultural employed today is below with details;

- **Autopilot Tractors**

New GPS system tractor and sprayer can accurately drive themselves through the field without driver. On the board of computer system, a user has told how wide a path a given piece of equipment will cover he will drive a short distance setting A and B points to make a line. The GPS system will have track to follow and it extrapolates that line into parallel lines set apart by the width of the tool in use. The tracking system is tied to the tractor's steering, automatically keeping it on track freeing the operator from driving. This allows operator to keep a closer eye on other things. Guidance is great for tillage because it removes human error from overlap, saving fuel and equipment hours.

- **Crop Sensors**

Crop sensors are going to help farmers apply fertilizer in a very effective manner, maximizing uptake. Sensing how your crop is feeling and reducing potential leaching and runoff into ground water. This is taking variable rate technology to the next level. Instead of making a prescription fertilizer map for a field before you go out to apply it, crop sensors tell application equipment how much to apply in real time. Optical sensors are able to see how much fertilizer a plant may need based on the amount of light reflected back to the sensor.

- **VRT and Swath Control Technology**

Through VRT and swath control technology, guidance really begins to show are turn on investment. Swath control is just what it sounds like. The farmer is controlling the size of the swath a given piece of equipment takes through the field. The savings come from using fewer inputs like seed, fertilizer, herbicides, etc. Since the size and shapes of fields are irregular you are bound to overlap to some extent in every application. The GPS mapping the equipment in the field already knows where it has been and swath control shuts off sections of the applicator as it enters the overlap area. VRT works in a similar fashion. Based on production history and soil tests a farmer can build a prescription GPS map for an input.

- **Monitoring and Controlling Crop Irrigation Systems via Smartphone**

Mobile technology is playing an important role in monitoring and controlling crop irrigation systems. With this modern technology, a farmer can control his irrigation systems from a phone or computer instead of driving to each field. Moisture sensors in the ground are able to communicate information about the level of moisture present at certain depths in the soil. This increased flexibility allows for more precise control of water and other inputs like fertilizer that are applied by irrigation pivots. Farmers can also combine this with other tech like VRT mentioned earlier to control the rate of water applied. It's all about more effective and efficient use of resources.

- **Biotechnology**

Biotechnology or genetic engineering (GE) is not new technology, but it is an important technology with much more potential yet to be unleashed. The form of genetic engineering, most of the people have probably heard of is herbicide resistance. Crops can be made to express toxins that control particular pests. Many employ toxin that is the same toxin found in some organic pesticides. It means a farmer won't have to make a pass through his fields to apply pesticide, which is not only saves on pesticide, but labor, fuel and wear on equipment too. There is another way to look at it would be that farmers who irrigate their crops can cut back on water use and not see yields suffer. Nitrogen use efficiency is a lot like that except you're doing it with fertilizer instead of water.

- **Documentation of Fields via GPS**

Due to on-board monitors and GPS the ability of document yields and application rates are becoming easier and more precise every year. In fact, farmers are getting to the point where they have so much good data on hand that and figure out what to do with all of it. The favourite form of documentation of every farmer's is the yield map and it sums up a year's worth of planning and hard work on a piece of colourful paper. The equipment's of harvesting rolls through the field and it calculates yield and moisture as it goes tying it in with GPS coordinates. The field is printed when finished a map of yield. These maps are often called heat maps. Now the farmer can see what varieties had the best, worst, or most consistent yield over varying conditions. Maps like this can tell a farmer how well a field's drainage system is working.

- **Ultrasounds for Livestock**

Ultrasound is not only for checking on baby animals in the womb, also can be used to discover what quality of meat might be found in an animal before it goes to market. The testing of DNA helps producers to identify animals with good pedigrees and other desirable qualities. For improving the quality of the herd, this information can be used to helps the farmer to improve quality.

Conclusion

Agriculture in the fragile, semi-arid tropics faces a vastly changing landscape in a globally competitive environment. Technology is an integral part of agriculture, and will remain a key factor for agriculture in the future. It is recognized that sustained agricultural research and technological improvements are critical in ensuring food security, and reducing poverty and hunger, without irreversible degradation of the natural resource base. The task therefore is to improve productivity and to diversify agriculture and the rural economy in order to create employment and income opportunities.

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Helping Agricultural Engineering Undergraduates towards Improved Classroom Presentations

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Abstract: In the process of assessing an individual at the college level, a learner has to make a presentation in English as a compulsory part of the evaluation process. These presentation skills are taught to the learners in the class as well as it is expected from them that they should use them in their actual presentations like seminars, workshops etc. This eventually helps them to get better academic results and make them more employable. Though the learners are seen enthusiastic to make academic presentations, they face performance related problems such as the use of appropriate field specific registers, the sequence of ideas and nervousness of out the lack of practice. As a part of the taught course, the researcher additionally incorporated presentation strategies to help his learners. In the methodology, class observation and questionnaire is circulated to find out the reasons for not giving a proper presentation. The purposive sampling is used for this experiment. Finally based on the decided criterion their performances are checked. It is found that these strategies were really helpful for the learners.

Keywords: Individual assessment, Evaluation process, classroom Presentation Skills, Field specific register, Presentation strategies

Introduction

"Presentation skills are the skills you need in delivering effective and engaging presentations to a variety of audiences. These skills cover a variety of area such as the structure of your presentation, the design of your slides, the tone of your voice and the body language you convey" (Journal of Applied Research for Business Instructors 8(2)

The researcher has been teaching undergraduates of B.Tech. students of Agricultural Engineering and Technology College since 2017. At under- graduation level the learners have to make presentations of their assigned works. In the curriculum, there are seminars for imparting communication and presentation skills amongst the learners. Two seminar courses of one credit each during VII and VIII semesters are awarded to the learners. Every learner has to deliver a seminar on a given topic in presence of students and elite faculty members. The main purpose of these presentations is to make the learner confident, employable and more professional in their respective field. It is observed that our learners are so eager to make presentations on their assigned works but have some performance related problems. At the time of class presentations, the following problems have been observed.

1. **Lack of field related register-** An agricultural Engineering has a special field related register for the all the courses. So many students do not get familiar with this register. At the beginning for them this register is totally new and they take time to remember such register. They need to practice it deliberately.

2. **Ideas and their sequence-** Ideas should be presented in a logical way. In the time of presentation, learners don't understand which idea should be presented at first and which should be second, third. They get confused, it might happen because of stress of presentation

3. **Less confidence-** When they start their presentations, they don't show any confidence in their performance. A fear reflects through their body language. The reasons might vary for individual-to-individual learners. It might happen because they rarely participate in any stage performances.

4. **No rehearsal-** They don't make any rehearsal of their presentations; it is inevitable to make rehearsal so feel more confident.

5. **Fear of stage performance-** Some learners are afraid of stage performance; on the stage they cannot utter a single word. We can also call it fear of public speaking.

6. **L1 (MT) influence-** It has been observed that some of the learners think in mother tongue language and then try to translate in English language. Majority are from semi-English medium school hence; they have natural tendency to think in Mother Tongue language.

7. **Extra information-** When they come for performance they want to share as much as possible information, in this situation they share so much information which not related to the topic.

8. **Lack of awareness of time-** They didn't make proper time management for the presentation. It is a time bound activity where you have to present yourself in given time.

9. **No knowledge of how to use body language-** Body language plays very important role in the presentation. Your eyes, hands, body movements, your gesture, posture all are very important. It makes a positive impact on the audience.

10. **Lack of knowledge of how to use presentation aids-** They don't use different aids for the presentation, with use of aids learner make a good impression on the audience; therefore, they need to know how to use them properly.

    - **Process of making presentation:** In the process of presentation, they got topic from their concern course teachers or they can also select their own by discussing with their teachers. At the beginning of the presentation, they have been asked to follow the five steps: viz., **Search -Research-Arrange-Write-Rewrite**
    - **Search**: Once they get the topic, they are asked to visit university or college library to search related material of the given topic. They are also been instructed to talk to their teachers or HOD or professor to get the clear ideas of their topic. They are asked to have only suitable data with them.
    - **Research:** They were asked to research deeply on the collected data, which is really helpful to them.
    - **Arrange:** The next step is, arrange the information in three parts i.e. introduction (the beginning), the middle (main body) and the end (conclusion).
    - **Write:** The next step will be making a possible outline of the topic in written form, working on the rough draft and make the final draft of presentation in written form or in the scripted form.
    - **Rewrite:** After completing the first draft, the researcher has some conversation with them regarding their draft making. He asked them to read their draft loudly, so we can point out some mistakes in the pronunciation of the words. In every week one hour is given to them, for three weeks this practiced has been done until these students get their topic ideas cleared and making a good and balanced performance. It is necessary to point out that though these students are from science faculty, for them this agriculture engineering register is totally new. Then they are asked work on time management, because for the individual given time is 10 to 15 minutes including question and answer session. They are also advised that they should think about possible questions which would be asked in the presentation.

The following strategies have been followed.

1. ***Proper plan of presentation-*** At this stage a learner should ask few questions to himself. What is the goal of my presentation? What is topic of my presentation? Who are my audience? What things I want to make in this presentation? When these questions are written down by a learner, he/she gets its clear idea. A proper plan of presentation is required. A learner should think deep of his own topic and continuously work on it. What he or she is trying to convince the present audience should be well planned. Here some physical factors should also be considered. These factors play very important role in the actual presentation, without them many times a presentation turns into fiasco. In physical factors a learner must get to know size of the presentation hall, what equipment are there? Which electronic equipment's like LCD, microphone, pointer, good light in the hall? Is there podium to put handouts, notes, laptop etc?

There three parts of any presentation

A. Introduction/ beginning B. Main body C. The conclusion.

We will see them one by one-

A. The first one is introduction or we call it beginning of the presentation. It is said that the first impression the last impression. Here we try to make rapport between a presenter and audience also you try to get their attention.

I. Signalling to start- A learner has to give audience signal that he is going to start his presentation for example a learner can start with this phrase like

- Shall we start now?
- Shall we begin?
- Let's begin?
- Can we start now?
- Right…well…okay…good…fine…great…etc.

II. Greeting the audience- At the beginning it is necessary to meet your audience by different ways of greeting.

- Hello to everyone
- Good morning,
- Good afternoon
- Good evening,
- Honourable panel members,
- Honourable chairman/chairwoman etc.

III. Self-introduction- A learner needs to introduce himself to the audience so they can recognize him as presenter.

For example, good afternoon everyone, I want to begin by introducing myself……

- I am a student …..
- My name is…….

IV. Tell the title and make introduction of subject- Here a learner should tell the title of his topic and make an introduction of subject. He can give a rough outline of his topic for example

- Today I am going to share with you………..
- Today I am going to talk about……….
- Central theme of my topic is………..
- I have a plan to talk about…….

V. how long you speak- Making presentation is time bound activity. Hence it is required that a learner should tell the audience estimated time it will take to presentation. You can say that for example

- My speech will last for…..
- My speech last about…..
- I will speak for……

VI. Acknowledgment- Those who help you in the making presentation, your teacher, colleagues with whom you work together.

VII. Tell your Objectives- the main goal of any presentation is to impart knowledge, the audience must comprehend and remember a certain kind of information. There are two purposes: a general mad a specific one (Carl Storz et al, 2002) for example a learner can use these expressions to tell his objectives

My purpose of reading this paper is….

- To give you outline…..
- To give you essential outline…….
- I want to explain

VIII- share your outline- When a learner shares his outline, audiences get to know his subject outline that what he is going to present in what forms. For example he can say

- My presentation is divided in three parts……..
- In first part I will talk about
- In the second part I will talk about….
- In the last parc I will talk about……….

IX- Question-answer session- a learner can tell the audience that there will be questions and comments from audience. He can say like this

- The last session will be open for question-answer…..
- I would like answer your questions….
- At the end I will give reply to questions from audience….

B. *Main body of the presentation*

I. Subject Knowledge- Whatever content you have, it should support your goal of the presentation. Many a time's presenters poured out content knowledge so limit the content because presentation is a time bound activity.

II. Limit the quantity of information- it is necessary that a learner should give enough information to the audience also remember to give more examples to get clear understanding of subject matter.

III. Arranging the ideas- A learner should arrange his ideas from known to unknown; from difficult to easy; from problem to solution etc. there must be logical sequence to follow.

IV. Connecting Ideas-sections- In the presentation it is always remembered that there is connection between ideas and sections. They are not different; they are bound together or we can say that they are interdependent. So, the learner should maintain that connection between ideas and section.

C. *The End or conclusion*

There will be four parts in the concluding remarks of presentation.

1. a brief summary-in summary, here a learner can make list of main points to remembered by them.
2. conclusion- here a learner can make commentary on the idea that developed by him in his presentation. He can also talk about recommendation etc.
3. Thanking the audience. Thanking audience for patiently listening
4. Questions and answers- once a brief summary and conclusion is finished, a learner should tell the audience that the session is open for question and answer. While dealing with question-answer session a learner should make sure that he has understood the question very well if not then request to repeat the question. A learner can use these expressions for the giving answers
   - That is a good question
   - How can I put it
   - I am glad to answer this question
   - Just a minute please etc.

2. ***Practice makes a perfect***- As the titles says practice makes a perfect man, in this part a learner should make request his friends, teachers, seniors, parents to observe his presentation and suggest improvements. He can also record his speech and listen later on.
3. ***Don't have anxiety***- Many times, it is observed that learners are well prepared but they don't give their best presentation because of anxiety. They can tackle with this issue by practicing more and more.
4. ***Don't be over enthusiastic***- Learners are well prepared but because of over enthusiasm they make some mistakes like they don't greet the audience or they forget the logical sequence of their presentation.
5. ***Greet your audience***- It is necessary to meet your audience by telling your name, topic name and other information. Because drawing their attention is useful for learner
6. ***Imitate good speakers***- While practicing this presentation, a learner should observe any good speaker and try to follow his good techniques of presentation.
7. ***Pay attention to pronunciation***- This is very important part of presentation, where learners make his overall impact through his voice. If microphone is used in hall then a learner should maintain his volume according to the size of the class.
8. ***Your class as a whole***- For undergraduate students, their class is the first stage for any presentation and among the friends they don't feel shy or they don't feel afraid.
9. ***Time management***- A learner should precisely manage his time because allotted time for everyone is same and within that span of time every learner should give his best performance.
10. ***Your body language- It is said "be natural and relax!"***- In the presentation, body language plays very vital role especially, learners eye contact, facial expressions, posture, movements, gesture etc. A learner should have smiling face but should not give a smile unnecessarily.
    - Eye contact- a learner should have a good eye contact with all the people who are present in the hall
    - Facial expression- a learner should have a natural and friendly expression on face. He can use different facial expressions like raising eyebrows indicates surprise,
    - Body posture- while presenting on stage the posture should be straight there must not be bent or lean
    - Movements- here, a learner can move one place to another place to keep the audience attention

    Negative body language- a learner should avoid negative body language-for instance

    - Unable to keep eye contact with audience- looking at notes, floor, at the board, at screen etc
    - Staring
    - Arm-movements
    - Shrugging shoulders

Methodology

Research question- This study focuses on the following research question

1. What are the problems of undergraduate agricultural engineering students in classroom presentation skills?

2. To what extend these strategies are effective for undergraduate agricultural engineering students?

Participants- In this study, one of the aims is to find out the problems of UG engineering students in the classroom presentation skills. We choose thirty students with non-probability purposive sampling. They are all from engineering college of VII and VIII semester. For these learners English was compulsory subject for secondary and higher secondary level (10+2+3).

Data Collection

A. Observation

In data collection, observation tool is used, this tool is used to observe the shortcoming in classroom presentation skills in the pre-test evaluation chart and what is the impact of the strategies implement for the better classroom presentation in the post-test evaluation. There is statistical analysis made of both tests in the form of mean (SD).

B. Questionnaire

The data collection tool questionnaire is circulated among the seventy-five students from them sixty-seven students have submitted the filled questionnaire, while giving back the information it was not made compulsory to write their names on the questionnaire.

Sr. No.	Questions	Answer "Yes" Number of students	Percentage	Answer "No" Number of students	Percentage
1	Do you greet the audience?	25	37.31	42	62.68
2	Do you make a clear introduction of the topic?	7	10.44	60	89.55
3	After making introduction do you get clear idea of your presentations?	11	16.41	56	83.58
4	Do you follow decided sequence of the presentation?	17	25.37	50	74.62
5	Are you aware about controlling volume, pitch and performance?	5	7.4	62	92.53
6	Do you use other presentation aids?	16	23.88	51	76.11
7	Do you see in the eyes of audience and follow awareness of public?	18	26.86	49	73.13
8	Do you follow general poise and bearing?	15	22.38	52	77.61
9	Do you study in depth of your presentation topic	25	37.31	42	62.68
10	Do you make proper conclusion?	22	32.83	45	67.16

Findings and Discussion

Findings from the questionnaire- Here, the questionnaire administered analysis said, a high number of learners do not greet the audience (62.68%), they do not make a clear introduction of the topic (89.55%),they do not get clear idea after making introduction(83.58%), they do not follow the decided sequence of the presentation (74.62%), they are not aware about controlling volume, pitch and performance(92.53%), they do not use other presentation aid (76.11%), they do not see in the eyes of audience and follow awareness of public(73.13%), they do not follow general poise and bearing (77.61%), they do not study in depth of the presentation topic(62.68%) and they do not make a proper conclusion(67.16%).

Findings from statistical analysis-

Subject	Number of the students	Mean score	Standard deviation
Pre-test	30	22	0.69
Post-test	30	39	2.11

Based on their previous knowledge of classroom presentation, the pre-test evaluation is made. In the pre and post-test same evaluation criteria (chart) is used for their individual presentation. After pre-test evaluation, the intervention is done where they were given training to how to present themselves. Here each student performance is checked and overall mean score was made. The mean (SD) score of the pre-test is (0.69) and post-test mean (SD) score is (2.11).

Thus, there is clear difference seen between learner's performance in pre and post-tests. They have shown improvement in the post test as result of training.

Limitation of the Study

This research was conducted on a small group of 30 students who are participated in the research process. They are all from the same institute. If any other institute covered in this experiment then it could provide more detail information. Again, another limitation of this research is the student data is collected through the close-ended questionnaire where students cannot reflect their opinions.

Recommendation

1. There should be workshop approach to be used for teaching classroom presentation skills
2. Also, we can introduce peer and group work instead of traditional individual practice of class presentation skills
3. It is also recommended that students should encouraged to participate in workshop, seminars and conference
4. Every course teacher should give learners opportunity for classroom presentation skills by conducting seminars, workshops.
5. Agriculture engineering colleges different department can co-ordinate each other for different seminars
6. Colleges should invite good speakers from same area or other areas

Conclusion

The paper has tried to identify the problem of undergraduate B.Tech. students of Agricultural Engineering in classroom presentation skills. It has also been observed that spoken English, lack of practice, lack of motivation and their family, educational background were the other reasons for not having good presentation skills. Here in this case students need motivation, proper guidelines and last but not the least students themselves feel that they need to work on their own draw backs and become good presenters.

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Appendix A

A final evaluation sheet for presentation

On basis of this criterion their performances were checked.

Evaluation sheet for oral presentation

Name of the presenter-

Date of presentation

The qualitative meaning of the number is as follows.

1-Poor 2-Average 3- Good 4- very good 5- Excellent

Sr. No.	Criterion	1	2	3	4	5
a.	Introduction to the topic					
b.	Clarity of the presentation					
c.	Sequence and continuity					
d.	Voice, speech and delivery					
e.	Use of other aids					
f.	Eye contact and audience awareness					
g.	Interaction of audience					
h.	General poise and bearing					
I	Knowledge of the subject					
j.	Style of concluding presentation					

(Table no.1) (Adopted from comprehension and communication skills in English by Dr. Shravan Kumar G, Padmasri S.M, and Ramesh Babu P.)

Appendix B

Questionnaire

Sr.No	Question	YES	NO
1	Do you make introduction of the topic?		
2	After making introduction do you get clear idea of your presentations?		
3	Do you follow sequence of the presentation?		
4	Are you aware about controlling voice, pitch and delivery?		
5	Do you use other aids?		
6	Do you see in the eyes of audience and follow awareness of public?		
7	Do you follow general poise and bearing?		
8	Do you study in deep of your presentation topic		
9	Do you make proper conclusion?		

(Table no.2) (Adopted from comprehension and communication skills in English by Dr. Shravan Kumar G, Padmasri S.M, and Ramesh Babu P.)

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Swot Analysis of Entrepreneurial Training in Veterinary Education : A Case Study

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Abstract: Veterinary undergraduate curriculum consists of an entrepreneurial training course (ETR) designed for the capacity building and skill development of BVSc & AH students in order to help them emerge as potential entrepreneurs as well as good veterinary physicians. A study was conducted to analyse the strengths, weaknesses, opportunities and threats (SWOT) of entrepreneurial training course implemented at the College of Veterinary and Animal Sciences, Mannuthy, during 2017-2019 using a survey-based questionnaire and statistical analysis using SPSS V.21. The target sample of the survey was 149 students registered for the course which provided entrepreneurial training in goat production, piggery, egger nursery, milk products, meat production and processing, rabbit rearing, animal feed production, poultry feed production and fodder cultivation. The findings of the survey revealed that students perceived entrepreneurial training as an efficient tool to earn skills for decision making, crisis management, team work, farmer interactions as well as marketing of livestock products. The learning environment was also appreciated for sufficient capital investment, infrastructure, resources, competent teachers and supporting staff. They also perceived that entrepreneurial training facilitated *e-learning* to co-ordinate their learning sessions through social media networking *Apps*, shared *Blogs, Vlogs* and *Facebook* posts on the entrepreneurial success stories of alumni trainees as opposite to classroom learning. The course teachers perceived that working with the students outside classroom provided them an opportunity for technology validation and refinement of their theoretical concepts. Based on these perceptions, SWOT factors were identified and categorised. The strengths included multidisciplinary expertise of teachers, technical competency of supporting staff, good reputation and infrastructure of the training centres, student rewards in the form of profit sharing and high-quality control of market-ready produces like feed, fodder, animals, meat and milk products. The weaknesses included neglect of aptitude and interest of students in training unit allocation, insufficient training units to cater to the student batch size, lack of diverse and novel options of entrepreneurship as per global trends and inadequate *e-learning* models in livestock entrepreneurship. Opportunities cited were increasing institutional allocations of funds and resources, premium pricing for produces under organic farming protocol and joint ventures with external organizations for up-scaling of produces. The threats included the shrinking priority of entrepreneurial education with periodic change in veterinary curriculum, lack of market for certain livestock products and the diminishing trend in livestock population and small holder animal farming. The study has attempted to provide a baseline for further planning on entrepreneurial education in institutes of higher professional learning. It also urges the requirement of changed faculty roles in veterinary and allied courses; focussing on constant refinement of their planning, project formulation, pedagogy and social media skills and an increased connectedness, community and collaboration among students and faculty to attain the goal of inculcating entrepreneurial spirits in academic spheres.

Keywords: Veterinary education, Entrepreneurship Training, Strengths, Weaknesses, Opportunities, Threats, SWOT

Introduction

Veterinary Science and Animal Husbandry is a coveted professional branch of science designed for the development of veterinary graduates with proper knowledge, technical skills, attitude and competence to serve the farming community towards the production of more meat, milk, eggs and wool. Realising the importance of recent global trend of initiatives like agro-business, entrepreneurships, start-ups and speciality services such as value-added meat and milk products, feed production, animal breeding farms etc., the nation-wide unified curriculum of BVSc & AH was supplemented with an entrepreneurial training course since 2006 to inculcate entrepreneurial skills in veterinary graduates. The initiative aimed at the evolution of a veterinary professional into a successful entrepreneur in the most critical times of under-employment or unemployment. Entrepreneurial training was provided as a non-credit course (ETR-321) in goat production, pig production, student's egger nursery, milk products and marketing, meat production and processing, rabbit rearing, animal feed production, poultry feed production and fodder cultivation. In this context, a survey-based perception analysis on entrepreneurial training was conducted with the following objectives:

1. Assessment of how the learner and the teacher accepted and valued the entrepreneurial training course as a learning and teaching tool to improve professionalism in veterinary education

2. A SWOT analysis of the entrepreneurial training in veterinary graduation based on the perceptions of students as well as the faculty co-ordinators.

Methods and Data Sources

The study aimed at analyzing the strengths, weaknesses, opportunities and threats of entrepreneurial training for veterinary education under VCI curriculum of 2006, implemented at the College of Veterinary and Animal Sciences, Mannuthy under Kerala Veterinary and Animal Sciences University. The nine entrepreneurial training courses were goat production, pig production, student's egger nursery, milk products and marketing, meat production and processing, animal feed production, rabbit rearing, poultry feed production and fodder cultivation. The student groups were expected to learn the practical skills under the supervision of course co-ordinators and market their finished farm produce to the stakeholders, with the profit or loss, if any, to be kept or borne by the students.

Study design and Sampling: A qualitative case research design study was conducted where questions were framed for a perception analysis among student trainees and the faculty course coordinators. The questionnaire was designed and pre-tested with a few respondents to test the robustness and modified accordingly. The participants of the research study were the third-year students of BVSc &AH programme enrolled in 2014 and 2015 (N=149) and the co-ordinating faculty (N=9) of College of Veterinary and Animal Sciences, Mannuthy under Kerala Veterinary and Animal Sciences University implementing the entrepreneurial training course in nine different units.

Perception analysis among students and faculty on ETR as a learning tool: A structured schedule was used to record the gender of the participant and the type of ETR course undertaken or involved with as the independent variables. The perception among respondents about the potential of ETR as an educational tool was taken as the dependent variable. A scale was developed for perception analysis of ETR as a learning tool with 51 items as statements pertaining to the four domains of (a) attainment of learning objectives and outcomes (b) nurture of learning environment (c) nurture of learning behaviour and (d) technology validation and refinement of teachers during entrepreneurial training. The scale developed was administered among the respondents to record their response to the statements on a four-point continuum *viz.*, strongly agree, age, somewhat agree and disagree with scores 4, 3, 2 and 1 respectively. The sum of the scores assigned to all of the statements by each respondent constituted his / her perception score. Based on the estimated mean score of the respondents and the expected score range for each domain, the respondents were classified into low, medium and high perception groups.

Identification, categorization and validation of SWOT factors: Based on the perception analysis, discussions with subject experts and teaching experts, a repository of the internal (strengths and weaknesses) and external (opportunities and threats) factors were identified and grouped into domains *viz.*, human resources, infrastructure, policy planning strategies, socio-economic factors and market-based strategies. The respondents were asked to rate these SWOT factors on a four-point continuum on a Likert scale with scores 4, 3, 2 and 1 *viz.*, 4 (extremely important), 3 (very important), 2 (somewhat important) and 1 (not important). The summation of the scores for a particular SWOT factor by all the respondents indicated the factor's score. The mean scores of the factors were estimated and the top-ranking items with mean score of 3.0 or above were identified and discussed as the most influential key factors in SWOT analysis.

Data collection and statistical analysis: The structured questionnaire was organized into three parts: (1) the social profile of the respondents like their status as student or faculty, their gender as well as the ETR unit they were involved with (2) the perception analysis of students and faculty on ETR as a learning tool and (3) the analysis of strengths, weaknesses, opportunities and threats (SWOT) of the entrepreneurial training course. Close-ended questions were utilized for the survey. The data were analyzed using SPSS version 21.

Results and Discussion

The empirical findings of the study are structured into three sections as analyzed below:

Profile of the respondents

The respondents belonged to two categories *viz.*, students and course teachers based on their involvement with the entrepreneurial training units. Students (N=149) actively performed the necessary operations related to agriculture and animal husbandry in the ETR units while the course teachers in charge of the units (N=9) supervised and guided the students of their units. Students were grouped based on their gender as well as the ETR activity they were involved with. Questionnaires were designed and administered to each category. Out of 158 questionnaires distributed, a total of 114 fully completed questionnaires were returned, of which 105 were filled by students and nine by the faculty respectively. This generated response rates of 70.47% among students and 100% among the faculty. The overall response rate was 72.15%.

The study revealed that majority of the student respondents were females (74.29%). It may be recalled in this context that over the last five years, there has been a national surge in the number of female students opting and enrolling in the course of Bachelor of Veterinary Science and Animal Husbandry (Sethumadhavan, 2018) and the same was true about the composition of student participants of entrepreneurial training. The results of the survey also indicated that women students appeared to be more enthusiastic than their male counterparts to participate in the evaluation of the course as a learning tool and expressed their desire on continuous acquisition and upgradation of entrepreneurial and business skills to make them future-ready.

There were nine functional units of entrepreneurial training and the student participation per unit ranged from 6 to 25. The range of profit generated from different units amounted to Rs. 150/- to Rs. 14,700/- per student. Pig production topped the chart in terms of student profit closely followed by egger nursery and rabbit rearing. In this context, it was revealed that students who belonged to the three training units which generated remarkable monetary profit actively participated in the survey while the other six entrepreneurial training units had lesser number of respondents. Since the maximum number of respondents turned out to be from the most successful units in terms of monetary benefits, it appeared that the satisfaction over the training output in terms of both learning and monetary rewards might have been the major propelling force of intrinsic motivation in the students to participate in the survey. The '*Earn While You Learn*' component in the entrepreneurial training can also be perceived as a great motivation for the students to undergo entrepreneurial training with interest and commitment.

Perception among students and faculty about the potential of entrepreneurial training as a learning and teaching tool

The study revealed that majority of the student respondents (85.71%) had a high level of perception about the potential of entrepreneurial training as a learning tool in veterinary education. Another 14.29 % had a medium level of perception and none expressed a low level of perception. Regarding achievement of learning objectives, students expressed a high appreciation towards earning of crucial skills for decision making, crisis management, team work, farmer interactions and marketing skills through entrepreneurial training. There was consensus among the students on the ability of entrepreneurial training to improve the infrastructure and resources like seed stock (animals, fodder slips, feed ingredients) for a good learning experience. The competent teachers and the sufficient autonomy designed for the system also ensured a good learning environment. Students also perceived that the entrepreneurial training modified their learning behaviour by way of effective usage of internet access for learning as opposite to classroom teaching. The social media networking through *WhatsApp* greatly coordinated the experiential learning sessions; *Blogs* and *Facebook* posts facilitated sharing success stories across batches and the online interaction with the alumni groups facilitated a greater success in the programmes.

All the faculty respondents (100%) had a high level of perception about the potential of entrepreneurial training as a teaching tool. There was a general agreement among the faculty that many of the theoretical concepts received better practicability and refinement while working with the students in different training units and hence entrepreneurial training led to greater technology validation and refinement among the faculty. Faculty also perceived that entrepreneurial training provided opportunities to refine their planning skills, project formulation skills and refinement of pedagogy for imparting teaching and guidance.

SWOT analysis of entrepreneurial training in veterinary education

The study mainly focussed on the SWOT analysis of entrepreneurial training implemented at the Mannuthy campus of Kerala Veterinary and Animal Sciences University during 2018-2020. The perceptions of the respondents regarding the strengths, weaknesses, opportunities and threats to entrepreneurial training were examined and SWOT factors were identified and categorised in line with some earlier reports (Sasidhar and Reddy, 2012).

Strengths of entrepreneurial training

As indicated in Table 1, the respondents agreed that highly competent teachers with multidisciplinary expertise (score: 4.0), adequate technically competent supporting staff (score: 3.8), reputation of the host centre/farm/institute (score: 3.75), good infrastructure and quality control systems of high standards of land, farms and laboratories (score: 3.70) and good monetary rewards from profit-sharing on successful completion of entrepreneurial training (score: 3.68) were the key strengths of the system.

The competency of the training faculty was rated as the most significant strength of the system and it can be inferred that teacher still enjoyed a pivotal role in controlling the learning atmosphere when it came to skill-oriented subjects like veterinary science. The study throws light on the fact that teachers with essential soft skills and multi-disciplinary knowledge in management subjects along with technically competent support staff are likely to emerge as the most valuable assets of entrepreneurial education in professional courses.

Weaknesses of entrepreneurial training

As indicated in Table 2, the respondents agreed that neglect of aptitude and interest of students in entrepreneurship training unit allocation (score: 4.0), biased allocation of entrepreneurial training solely based on academic merit of students (score: 3.95), lack of sufficient number of entrepreneurial training units to cater to the student batch size (score: 3.88) and lack of diverse options of entrepreneurship as per the global trends (score: 3.68) were the key weaknesses of the system.

The study revealed that there was severe dissent on the part of the students regarding the unbalanced approach of allocating highly profitable entrepreneurial training units to meritorious students only and the average learners left with meek choices. This indicated that institutional policy decisions on entrepreneurial training and education need to be reviewed periodically to correct the disparities and discriminations in it's implementation. Similarly, lack of adequate number of training units to suit the student batch-size as well as diverse themes or options for global entrepreneurship avenues was identified to weaken the entrepreneurial education system by deepening the disparities in skill-building opportunities.

Opportunities of entrepreneurial training

Furthermore, in Table 3, the respondents agreed that increasing institutional allocation of fund and resources for entrepreneurial training (score: 3.63), premium pricing for the livestock products from entrepreneurial training units (score: 3.52), the rising demand for organic farm animal produce from entrepreneurial training units (score: 3.50) and growing prospects of commercial upscaling of the farm animal produce from entrepreneurial training units (score: 3.31) were the top ranked opportunities of veterinary entrepreneurial education.

The study revealed that increasing the allocation of funds and resources in Universities for the expansion of entrepreneurial education would help to accommodate more diverse options of entrepreneurship as per the global initiatives. Premium pricing and organic labels for the produces from entrepreneurial sessions can also enhance the sustainability of the system.

Threats of entrepreneurial training

As indicated in Table 4, the respondents revealed that the changing priority of entrepreneurial training with periodic change in curriculum (score: 3.86), lack of market for certain produces from entrepreneurial training units (score: 3.30) and the diminishing trend in livestock population and small holder animal farming (score: 3.10) were the top threats to veterinary entrepreneurial education.

The study found that there was a serious threat to the continuation of entrepreneurial training courses in veterinary undergraduate education with the changed priorities in the new and revised VCI curriculum of 2016. Shrinking livestock population and small holder farming systems also were other areas of concern which had a profound impact on the policy making for the continuity of entrepreneurship education programmes in veterinary education.

Limitations of the study

The outcomes of the study have identified SWOT factors for the entrepreneurial training in undergraduate veterinary education. However, the study was limited to the Mannuthy campus of Kerala Veterinary and Animal Sciences University that implemented entrepreneurial training course to undergraduates. The target students belonged to only two batches of IIIrd year BVSc & AH. The participation of student-trainees in the filling up of the questionnaire was mainly voluntary, which might have influenced the representativeness of the sample population. It was also evident that the students, who were involved with the entrepreneurial training units of their interest and aptitude, filled the questionnaire, while those who were not interested did not participate in the survey.

Summary and Conclusion

Within the context of SWOT analysis of the entrepreneurial training of BVSc and AH curriculum, the key strengths included multidisciplinary expertise of teachers, technical competency of supporting staff, good reputation, infrastructure and quality control systems of the training centres and student rewards in the form of profit sharing. The weaknesses included neglect of aptitude and interest of students in training unit allocation, insufficient training units to cater to the student batch size and lack of diverse and novel options of entrepreneurship as per global trends. Opportunities cited were increasing institutional allocations of funds and resources, premium pricing for produces under organic farming protocol and joint ventures with external organizations for up-scaling of produces. The threats included the shrinking priority of entrepreneurial education with periodic change in veterinary curriculum, lack of market for certain livestock products and the diminishing trend in livestock population and small holder animal farming. Strengths and Opportunities identified could be utilized effectively to provide competitive advantage to entrepreneurship training and create world-class entrepreneurs. Weaknesses and Threats may lead to situation-specific disadvantages to impede the system and hence need to be eliminated or minimized.

Implications and Recommendations

Entrepreneurial training has been enforced in many Veterinary Universities since 2006 but no research has been carried out so far to analyze the strengths, weaknesses, opportunities and threats of the system. The study hence holds the implication that it provides a baseline study to help stakeholders, educators and curriculum experts in veterinary, agriculture and allied sectors for policy planning in entrepreneurial education.

Based on the SWOT analysis and related discussions, the study recommends that consultative mechanisms may be set up to:

1. Review the veterinary curriculum periodically and include more diverse courses on entrepreneurship development as per the latest global trends
2. Focus on the capacity building of faculty and supporting staff for implementation of entrepreneurial education in veterinary universities with emphasis on teaching methodologies in experiential learning as well as management subjects
3. Improve the infrastructure and *e-learning* facilities in veterinary university campuses to encourage contextual learning experiences outside classrooms to generate successful entrepreneurs
4. Increase the connectedness, community and collaboration of students and faculty with successful alumni entrepreneurs for inculcating entrepreneurial spirit in academic spheres
5. Create good *e-learning* and *e-marketing* models in livestock entrepreneurship
6. Formulate appropriate rules and regulations for the implementation of entrepreneurial education in institutes of higher professional learning in veterinary, agriculture and allied courses.

Table 1. Key strengths of entrepreneurship training in Veterinary education

Sl No.	Strengths	Score
1	Highly competent teachers with multi-disciplinary expertise	4.0
2	Adequate technically competent supporting staff at ETR units	3.80
3	Reputation of the host Centre / Farm / Institute	3.75
4	Good infrastructure and Quality control systems in farms and labs	3.70
5	Monetary rewards from profit sharing on successful completion	3.68

Table 2. Key weaknesses of entrepreneurship training in Veterinary education

Sl No.	Weaknesses	Score
1	Neglect of aptitude and interest of students in allocation of ETR unit	4.0
2	Biased allocation of training units solely on academic merit	3.95
3	Lack of sufficient number of units to cater to the batch size	3.88
4	Lack of diverse options as per global trends of entrepreneurship	3.68

Table 3. Key opportunities of entrepreneurship training in Veterinary education

Sl No.	Opportunities	Score
1	Increasing institutional allocation of funds and resources for ETR	3.63
2	Premium pricing for ETR products	3.52
3	Rising demand for organic farm animal produce from ETR	3.50
4	Growing prospects of commercial up-scaling of ETR products	3.31

Table 4. Key threats to entrepreneurship training in Veterinary education

Sl No.	Threats	Score
1	Changing priority of entrepreneurship training with periodic change in VCI curriculum	3.86
2	Lack of market for certain produces of entrepreneurship training	3.30
3	Diminishing livestock population and small holder animal farming	3.10

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Theme II

Research and Innovation in Agriculture

Soil Quality Index of Different Land Uses of Kanamadi South Subwatershed of Karnataka

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Abstract: A study was undertaken to assess soil quality of different land uses at Kanamadi South sub-watershed of northern dry zone of Karnataka. An exhaustive field survey was carried out to know the type and distribution of soil for its mapping. Fifty soil profiles across various physiographic units were dug to study the morphological, physical and chemical properties of soil. The data obtained from the various soil analyses, except for the inherent soil properties like soil depth, were reduced to a minimum data set by standardized principal component analysis (PCA) using SPSS software (SPSS 16). The principal components (PCs) characterized by high eigenvalues and comprising variables with high factor loading were assumed to be the variables that best represented the system attributes. Therefore, PCs with eigenvalues >1.0 were selected. Within each PC, only variables that had consistently highly weighted factor loading were retained for the minimum data sets and the selection was made for factor loading values for all PCs. Among the soil quality indicators, CEC, Base saturation, silt, clay and free $CaCO_3$ were identified as important ones. The medium SQI *i.e.,* 0.60 = SQI =0.75 was recorded in the following mapping units: 0.67 in DMTmB2g1Ca; 0.64 in KGRmB2; 0.69 in KGRmB2g1; 0.66 in NHLmB2 and THLmB2g1Ca; 0.68 in THLmB2; 0.65 in THLmB2g2Ca; 0.61 in DMTmB2g2Ca; 0.74 in BBLmB2; 0.69 in NDNmB2; 0.67 in NDNmB2g1Ca; 0.71 in TSLmB2g1Ca and SRDmB2g1Ca; 0.72 in SRDmB2 and KRJmB2g1Ca; 0.73 in KRJmB2. The lowest SQI (0.58) was recorded in HNTmB2g1 Ca. The highest SQI was recorded with DMTmB2g1 (0.77) and RPRmB2(0.78) mapping units. Overall soil quality indices of the mapping units indicated that the soil quality of major mapping units ranged from medium to high in the study area. Higher soil quality of the study area was due to fallow period and lower tillage intensity. Poor crop residue retainment and its management and moderately slopping as well as soil erosion losses might have resulted in low soil quality. The soil quality indices of the open shrub land and agriculture land use was medium 0.62 and 0.68 respectively, whereas the soil quality index of plantation land was 0.78.

Key words: Kanamadi South sub-watershed, plantation, open shrub, agriculture, principal component analysis.

Introduction

Soil quality is one of the three components of environmental quality, besides water and air quality. Soil quality defined as "the capacity of a soil to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health".

Assessment of soil quality provides a scientific tool for the evaluation of soil resource management, considering the societal demands of various benefits that soil provides to humankind when it is properly managed. The valuation of soil quality hence becomes connected to the valuation of the services ecosystem provided by soil. Thus, a mathematical or statistical framework was put forward in early 1990s to estimate Soil Quality Index (SQI).

Kanamadi South sub-watershed is located in tikota hobli of Vijayapura taluk of Vijayapura district in Karnataka was selected as study area. This area is well known for pomegranate and grapes production. The sub-watershed with a total area of 4170.17 ha lies between 75^0 21' and 75^0 26'30" East longitudes and 16^0 51' and 16^0 55'30" North latitudes.

Information of soils of the study area, in respect to their extent on particular landscape and their characteristics in terms of potentials and constrains is therefore required so that the precious soil resources may be put to judicious use without allowing it to degrade further.

Materials and Methods

General description of the area

Kanamadi South sub-watershed is located 39.2 km away from Vijayapura (Bijapur), headquarter town of Vijayapura District. This area lies in Northern dry zone of Karnataka and has hot arid ecosystem with hot and dry summers and mild winters (K4D2) and belongs to the sub region 6.1 (K4Dd3) North Karnataka Plateau.

Soil Survey

A detailed soil survey of Kanamadi South sub-watershed was carried out using IRS P6 LISS-IV image and Vijayapura district toposheet. The image and scanned toposheet were geocoded and subset was created in ArcGIS 10.2 on a 1: 12,500 scale. The area was then intensively traversed and 50 pedon location were fixed on soil heterogeneity. At each pedon location, a fresh profile was opened and detailed morphological studies as described by USDA Soil Survey Manual (2000) and horizon-wise samples were collected and analyzed for physico-chemical parameters.

Assessment of soil Quality Index

According to Ditzler and Tugel (2002), soil quality can be assessed through the use of key of soil indicators, which reflect important soil processes. In the study, the technique proposed by Wander and Bollero (1999) and Andrews *et al.* (2002) were employed to construct a soil quality index of the study area. Three main steps of this technique are to (i) select a minimum data sets (MDS) of indicators the best represent the soil functions; (ii) The score the MDS indicators based on their performance of soil functions; and (iii) integrate the indicator score into a comparative index of soil quality (Andrews *et al.*, 2002)

To select a representative MDS for the soil mapping units in the study area, the analyzed soil attributes were subjected to statistical analysis in which a principal components analysis (PCA) of selected soil attributes was made (Doran and Parkin, 1994). The Principal components (PCs) for a data set are defined as linear combinations of the variables that account for maximum variance. It was assumed that PCs receiving high values best represent system attributes (Andrews *et al.*, 2002). Therefore, only PCs with eigen values ≥ 1 was examined. Eigen values are the amount of variance explained by each factor, while communities estimate the portion of variance in each soil attribute explained by the factors (Brejda *et al.*, 2000). Principal components analysis for the factor extraction using the factor-data reduction procedure in the SPSS 16.0 (SPSS Inc.) software.

In the PCA, each component received a weight or factor loading that represents its contribution to the PC. As suggested by Andrews *et al.*, (2002), only the highly weighted variables from each PC were retained. Highly weighted variables were defined as those within 10% of the highest factor loading. When more than one variable was retained with in a PC, their significance correlation was observed. If these weighed variables were not correlated ($r<0.6$), then each was considered important and was retained in the MDS. Among the significantly correlated variables with a PC, the variable with a highest sum of correlation coefficients was chosen for the MDS (Andrews *et al.*, 2002)

The second step was to score the MD indicators and the conversion of soil data into a 0 to 1 scale. In this case, the equation proposed by Diack and Stott (2001) were used. These equations are:

$y = (x-s)/(1.1t-s)$ for 'more is better'

$y = 1-\{(x-s)/(1.1t-s)\}$ for 'less is better'

where, y is the score of soil data; x is the value of the soil property converted into a 0 to 1 scale value; s is the lowest possible value of the soil property, taken as 0 for this study; and t is the highest value for that soil property.

The third step was to integrate the score and calculate the soil quality index (SQI) using the formula described by Andrews et al., (2002):

$$SQI = \sum_{i=1}^{n} Wi \times Si$$

Where, W is the PC weighing factor and S is the indicator score (namely y). The weighing factor (i.e the weight of the PC) is determined by the percent of variation in the data explained by variation explained by all PC's eigen vectors >1 .

Results and Discussion

SQI of soil mapping units

The data obtained from the various soil analyses, except for the inherent soil properties like texture and soil depth, were reduced to a minimum data set by standardized principal component analysis (PCA) using SPSS software (SPSS 16). The principal components (PCs) characterized by high eigenvalues and comprising variables with high factor loading were assumed to be the variables that best represented the system attributes. Therefore, we selected only PCs with eigenvalues >1.0. Within each PC, only variables that had consistently highly weighted factor loading were retained for the minimum data sets and the selection was made for factor loading values for all PCs.

A significant correlation was observed among soil properties which helped in the identification of eigenvalue factor pattern. The order in which factors were interpreted was determined by the magnitude of their eigenvalues. The signs of the eigenvalues indicated whether the variables made either negative or positive contribution to the factor. The total variation explained by four PCs was 80.05 per cent. Among them, the highest proportion of variance was explained by PC 1 (44.77 %) followed by PC 2 (16.15 %), PC 3 (12.03 %) and PC 4 (7.09 %). The computed factor weightings were 0.559 for PC 1, 0.201 for PC 2, 0.150 for PC 3 and 0.088 for PC 4. These four PCs best explained the importance of soil quality indicators in the study area.(Table 1).

The highest loading factor observed in PC 1 was CEC which was considered as one of the minimum data set of the study area. Similar results was reported by Ray *et al.* (2014). The higher positive loading of cation exchange capacity was due to higher frequency of correlation by exchangeable calcium, exchangeable magnesium and base saturation with majority of the soil properties. The importance of cation exchange capacity in the management of soils for agricultural purposes was highlighted in soil classification by including it as qualifier at the family level (Soil Survey Staff, 2014). The higher loadings of >0.40 in cation exchange capacity was due to higher association with exchangeable calcium (0.513), magnesium (0.657), potassium (0.206) and base saturation (0.083). Exchangeable Na factor was termed as dispersion factor and it was the only factor that was not classified under any of the other factors. It was not a major factor in soil management so long as it remains very low in the soils of the study area. Similar results were reported by Jude and Bassey (2011).

In PC 2, the soil parameters *viz.*, base saturation, Exchangeable calcium and SEB recorded high weightage while, lower weightage was recorded with pH. ., base saturation , Exchangeable calcium and SEB were highly correlated with each other but higher weightage factor was recorded for base saturation. Similar results were reported by Ray *et al.* (2014).

In case of PC 3, higher weightage factor was reported for silt (-0.710) and clay (0.642) which did not correlated with each other (correlation more than 0.65) hence both factors were retained in this PC. The eigen values under third loading factor had nearly 50 per cent of variables showed positive impact on the principal component (Jude and Bassey, 2011).

In PC 4, the soil parameters with high weightage were mean weight diameter, dispersion index and maximum water holding capacity while, calcium recorded relatively lower weightage. Among the variables, Free $CaCO_3$ recorded the highest positive contribution (0.837) followed by MWHC (0.502), sand (0.354) and Ex. Na (0.250). The negative contributions were recorded for silt (-0.380), SEB (-0.180), Ex. Mg (-0.115) and pH (– 0.024).

Soil pH and CEC are the important factors closely associated with the availability of nutrients (Ibia *et al.*, 2008). Andrews *et al.* (2002) reported electrical conductivity as an important soil quality indicator when the soils are alkaline (pH >7.5). He opined that changes in electrical conductivity are likely due to management decision. Generally, it was suspected that low factor loadings could affect classification of soil properties. Management and pedological factors assist in designing of experimental research and planning of site-specific production strategies for optimum output.

Among the soil quality indicators, Silt, clay, CEC, Base saturation and Free $CaCO_3$ were identified as important indicators. Results were in accordance with Singh and Khera (2008). ESP and bulk density were the factors considered responsible for reduction in soil quality of the study area. This might be due to lower organic matter resulted from higher decomposition rate and lower application of organic manures. This further resulted in poor soil particle aggregation and favoured higher dispersion.

Based on the overall soil quality indices, the mapping units HNTmB2g1Ca was grouped under low soil quality category due to located in lower elevation and affected by sheet erosion.

The medium SQI was recorded in DMTmB2g1Ca, KGRmB2, KGRmB2g1, NHLmB2 , THLmB2g1Ca, THLmB2, THLmB2g2Ca, DMTmB2g2Ca, BBLmB2, NDNmB2, NDNmB2g1Ca, TSLmB2g1Ca , SRDmB2g1Ca, SRDmB2 , KRJmB2g1Ca KRJmB2.mapping units. The medium soil quality observed in these mapping units was due to moderate slope with slight erosion and slight slope and moderate management practices. The higher soil quality indices were observed in DMTmB2g1 and RPRmB2 mapping units. This might be due to higher soil depth, clay texture (having better moisture and nutrient holding capacity, well aggregated structure) higher organic carbon content and higher base saturation compared to other mapping units. The soil quality indices of different mapping units were evaluated based on ratings *i.e.*, 0.40 = SQI =0.59 as low; 0.60 = SQI =0.75 as medium and SQI = 0.76 as high. The soil quality index of major mapping units ranged from medium to high (0.56 to 1.00) in the study area (Table 2). Majority of the mapping units were rated as medium in terms of soil quality.

The medium SQI *i.e.*, 0.60 = SQI =0.75 was recorded in the following mapping units: 0.67 in DMTmB2g1Ca; 0.64 in KGRmB2; 0.69 in KGRmB2g1; 0.66 in NHLmB2 and THLmB2g1Ca; 0.68 in THLmB2; 0.65 in THLmB2g2Ca; 0.61 in DMTmB2g2Ca; 0.74 in BBLmB2; 0.69 in NDNmB2; 0.67 in NDNmB2g1Ca; 0.71 in TSLmB2g1Ca and SRDmB2g1Ca; 0.72 in SRDmB2 and KRJmB2g1Ca ; 0.73 in KRJmB2.

The lowest SQI (0.58) was recorded in HNTmB2g1Ca . The highest SQI was recorded with DMTmB2g1 (0.77) and RPRmB2(0.78) mapping units.

Overall soil quality indices of the mapping units indicated that the soil quality of major mapping units ranged from medium to high in the study area. Higher soil quality of the mapping units was due to lower cropping and tillage intensity in the study area. Poor crop residue management and moderately slopping as well as soil erosion losses might have resulted in low soil quality (Denis *et al.*, 2015).

Soil quality index under different land uses

The soil quality index under different land uses ranged from 0.62 in open shrub land to 0.72 in plantation areas. (table 2 and fig.2). The SQI of open shrub and agriculture was medium (0.62 and 0.68 respectively). The plantation land had high SQI of 0.78. The plantation showed higher soil quality than agriculture because of their permanent land cover with minimal land disturbances. The high exposure of open land to sunlight had resulted in higher organic matter decomposition and lack of nutrient addition through crop residues, crop leaf shedding and application of fertilizers had resulted in low soil quality of open shrub lands.

Singh *et al.*(2014) reported the land use impact on soil quality in eastern Himalayas had higher SQI in forest land followed by plantation and agriculture land use. Similarly, Mandal and Jayaprakash (2012) reported eucalyptus plantation had high SQI 353 out of 400 followed by arable cropland (SQI: 316) and pasture land (SQI:228). The soil quality index for arable land that was under continuous crop production was 12 percent lower than plantation. The results of present study are in conformity to these earlier findings.

Conclusions

A study was undertaken to assess soil quality of different land uses at Kanamadi South sub-watershed of northern dry zone of Karnataka. Among the soil quality indicators, CEC, Base saturation, silt, clay and free CaCO3 were identified as important ones. Overall soil quality indices of the mapping units indicated that the soil quality of major mapping units ranged from medium to high in the study area. Higher soil quality of the study area was due to fallow period and lower tillage intensity. Poor crop residue retainment and its management and moderately slopping as well as soil erosion losses might have resulted in low soil quality. The soil quality indices of the open shrub land and agriculture was medium 0.62 and 0.68 respectively, whereas the soil quality index of plantation land was 0.78.

Table 1: The principle component (PC) analysis of soil quality indicators

Components	PC 1	PC 2	PC 3	PC 4	
Eigen value	6.306	2.151	1.644	1.525	
Proportion of variance (%)	44.772	16.155	12.031	7.093	
Cumulative proportion (%)	44.772	60.926	72.957	80.050	
Weightage	0.559	0.201	0.150	0.088	
	Eigenvector variable				Communalities
Sand	-0.296	0.007	0.226	0.354	0.264
Silt	-0.211	-0.151	**-0.710**	-0.380	0.716
Clay	0.418	0.016	**0.642**	-0.009	0.587
BD (Mg m^{-3})	0.189	-0.028	0.020	0.063	0.041
Field capacity (%)	-0.066	-0.064	0.518	0.155	0.301
MWHC (%)	0.022	0.266	0.635	0.502	0.726
pH	-0.010	0.001	0.082	-0.024	0.007
EC (dS m^{-1})	0.205	-0.049	-0.081	0.021	0.052
OC (%)	-0.005	0.438	-0.147	0.165	0.241
Free $CaCO_3$ (g kg^{-1})	0.329	0.340	-0.138	**0.839**	0.947
Ex. Ca (cmol (p^+) kg^{-1}	0.513	0.687	0.197	-0.023	0.775
Ex. Mg (cmol (p^+) kg^{-1}	0.657	0.203	-0.052	-0.115	0.489
Ex. Na (cmol (p^+) kg^{-1}	-0.020	-0.050	0.074	0.250	0.071
Ex. K (cmol (p^+) kg^{-1}	-0.206	-0.062	0.258	0.028	0.114
SEB	0.709	0.637	0.203	-0.180	0.982
CEC (cmol (p^+) kg^{-1}	**0.937**	0.205	0.200	-0.135	0.978
ESP (%)	-0.221	-0.179	0.005	0.267	0.152
BS (%)	-0.083	**0.971**	0.097	-0.136	0.978

EC (Electrical conductivity dS m^{-1}); OC (Organic carbon %); $CaCO_3$ (Calcium carbonate g kg^{-1}); Ex.Ca (Exchangeable Calcium cmol (p+) kg^{-1}); Ex. Mg (Exchangeable Magnesium cmol (p+) kg^{-1}); Ex. Na (Exchangeable Sodium cmol (p+) kg^{-1}); Ex. K (Exchangeable Potassium cmol (p+) kg^{-1}); CEC (Cation exchange capacity cmol (p+) kg^{-1}); SEB (Sum of Exchangeable Bases); ESP (Exchangeable sodium percentage); BS (Base saturation %); BD (Bulk density Mg m^{-3});MWHC (Maximum water holding capacity %).

Table 2: Soil quality index (SQI) of the mapping units of Kanamadi south sub watershed

Sl. No	Mapping units	SQI	Sl. No	Mapping units	SQI
1	DMTmB2g1	0.77	11	BBLmB2	0.74
2	DMTmB2g1Ca	0.67	12	NDNmB2	0.69
3	DMTmB2g2Ca	0.61	13	NDNmB2g1Ca	0.67
4	KGRmB2	0.64	14	TSLmB2g1Ca	0.71
5	KGRmB2g1	0.69	15	SRDmB2	0.72
6	NHLmB2	0.66	16	SRDmB2g1Ca	0.71
7	THLmB2	0.68	17	KRJmB2	0.73
8	THLmB2g1Ca	0.66	18	KRJmB2g1Ca	0.72
9	THLmB2g2Ca	0.65	19	HNTmB2g1Ca	0.58
10	RPRmB2	0.78			

Table 3 : Soil quality index of different land uses

Sl. No	Land use	SQI
1	Agriculture	0.68
2	Plantation	0.78
3	Open shrub	0.62

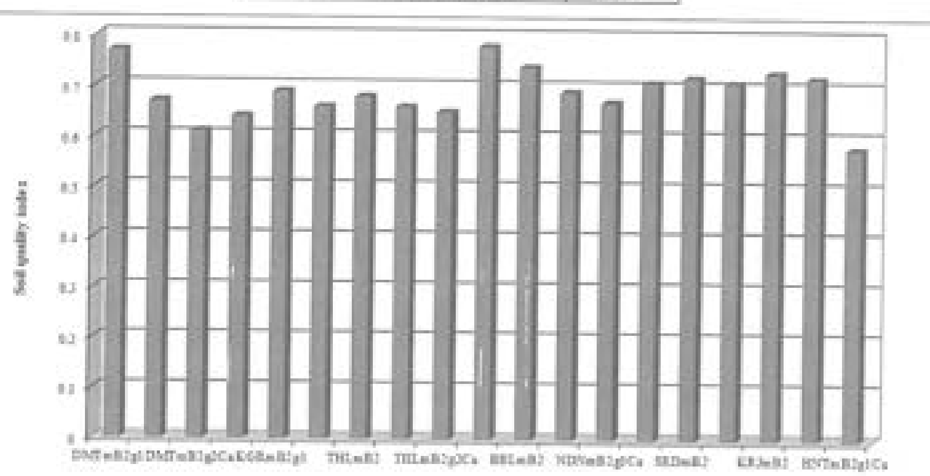

Fig. 1. Soil quality index of mapping units in Kanamadi South sub-watershed

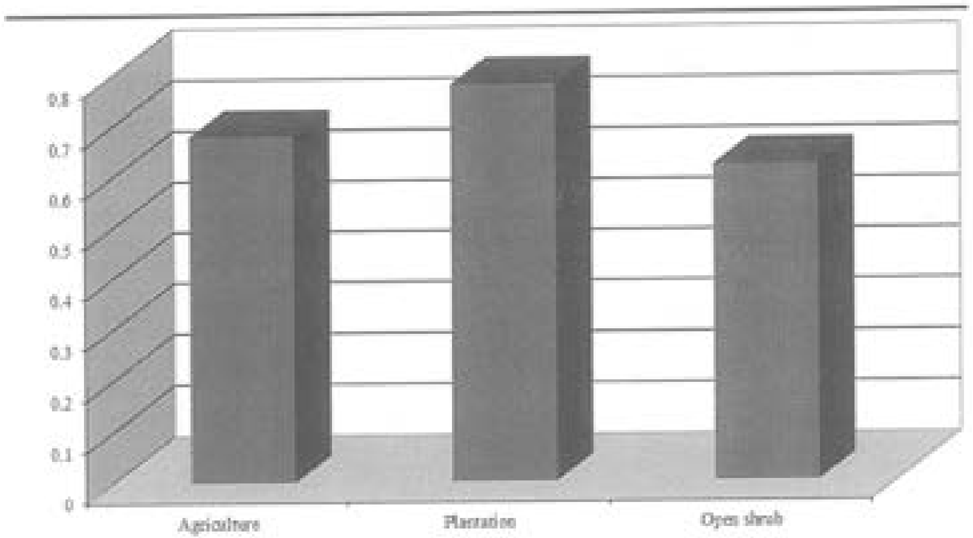

Fig. 2. Soil quality index of different land uses in Kanamadi South sub-watershed

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Organic Extracts for the Management of Bollworm Complex on Cotton

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Abstract: The research experiment was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Kharif* season of 2019-20. The experiment was laid in Randomized Block Design with eight treatments replicated thrice. Three treatment sprays were applied at 10 days interval to study the efficacy of organic extracts against bollworm complex of cotton. Among the different treatments application of Dr. PDKV- Entomology formulation proved effective in minimizing the bollworm complex damage in green fruiting bodies. However, this treatment was found at par with Brahmasthra extract and Panchpatre extract. Whereas, Broad-spectrum formulation and Neem seed extract appeared as next better treatments in this respect. These were followed by treatment of Garlic-Chilli extract and Cow urine found at par with each other. The maximum per cent bollworm complex damage was recorded in untreated control. The highest seed cotton yield was obtained from the plots treated with Dr. PDKV-Entomology formulation. The next effective treatments were Brahmasthra extract and Panchpatre extract. The present findings indicated that these organic extracts can be suitably incorporated in integrated pest management programme to protect the cotton crop from bollworm complex.

Key words: bollworm complex, cotton, ICBR, organic extracts

Introduction

Cotton is the most important cash crop in India. It plays a dominant role in the industries and agricultural economy of the nation, contributes 1/3rd of total foreign exchange earning of India (Mayee and Rao, 2002). India is the largest cotton growing country in the world with 35.29 per cent of world cotton area. Average productivity of cotton in India is 524 kg lint per hectare, which is considerably low when compared to world average of 766 kg lint per hectare (Anonymous, 2018). Damage inflicted by insect pests is one of the major constraints in attaining high production of seed cotton. The cotton bollworms are the major pests limiting cotton productivity worldwide. Among these the American bollworm, *Helicoverpa armigera* (Hubner) is considered as an International pest having a damage potential causing 60- 80 per cent yield losses.This pest has developed resistance to almost all groups of insecticides (Vennila et al., 2004). The avoidable yield losses due to *Earias vittella* (Fabricius) have been estimated to the tune of 44 per cent in *Gossypium hirsutum* (Shera, 2009). The pink bollworm *Pectinophora gossypiella* (Saunders) is the most destructive pest of cotton in later stages of the crop growth. It causes a locule damage of 37.5 per cent and 13.58 per cent on non-*Bt* and *Bt*-cotton, at 160 days of planting resulting into heavy loss in cotton production (Naik et al., 2014).

Insect pest management in cotton has traditionally been relied upon synthetic insecticides. The use of synthetic insecticides in crop protection programs around the world has resulted in disturbances of the environment, pest resurgences, pest resistance to pesticides and lethal effect to non-target organisms in the agro-ecosystems in addition to direct toxicity to users. Contrary to the problems associated with the use of synthetic chemicals, botanicals are environmentally safe, renewable, inexhaustible, indigenously available, easily accessible, largely non-phytotoxic, systemic ephemeral thus readily biodegradable, relatively cost effective and hence find a very promising role as a plant protectant in the strategy of integrated pest management (Saxena et al., 2014). The deleterious effects of crude plant extracts on insects are manifested in several ways, including toxicity, feeding inhibition and growth inhibitors (Wheeler and Isman, 2001). Therefore, the present study was planned to evaluate the organic extracts against bollworm complex of cotton.

Material and Methods

The research trial on "Organic Extracts for the Management of Bollworm Complex on Cotton" was conducted on the farm of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *Kharif* season of 2019-20. The experiment was laid in Randomized Block Design with eight treatments replicated thrice. The treatments included were, Brahmasthra extract @ 2 liters/100 lit of water, Panchpatre extract @ 2.5 liters/100 lit of water, Garlic–Chilli extract @ 2.5 liters/100 lit of water, Broad-spectrum formulation @ 1.6 liters/100 lit of water, Dr. PDKV-Entomology formulation @ 2.5 liters/100 lit of water, Neem seed extract @ 10 liters/100 lit of water, Cow urine @ 12.5 liters/100 lit of water along with untreated control. Three treatment sprays were applied at 10 days interval to study the efficacy of organic extracts against bollworm complex of cotton. The observations were recorded at an interval of 3, 7 and 10 days after spraying. Seed cotton yield data was recorded from each of the net plot to find out most effective treatment for the management of bollworm complex of cotton.

Results and Discussion

Cumulative effect of organic extracts on bollworm complex damage in green fruiting bodies

Three days after spray

The data displayed in Table 1 pertaining to cumulative effect of organic extracts against bollworm complex at three days after spray revealed that Dr. PDKV- Entomology formulation proved effective in recording the minimum damage of 4.42 per cent in green fruiting bodies. However, this treatment was found statistically equal with Brahmasthra extract (4.58%) and Panchpatre extract (4.87%). This was followed by the treatment of Broad-spectrum formulation recording damage of 6.02 per cent. Next in order of efficacy were the treatment of Neem seed extract (6.26%) and Garlic-Chilli extract (6.53%). The plots treated with Cow urine recorded comparatively highest bollworm complex damage (8.04%) which was found at par with untreated control with 9.95 per cent damage in green fruiting bodies.

Seven days after spray

The data on cumulative effect of different treatments against bollworm complex at seven days after spray (Table1) showed that treatment of Dr. PDKV- Entomology formulation, Brahmasthra extract and Panchpatre extract proved equally effective in recording minimum damage in green fruiting bodies *i.e.* 3.87, 4.11 and 4.59 per cent, respectively. Whereas, Neem seed extract (5.62%), Broad-spectrum formulation (5.71%) and Garlic-Chilli extract (6.04%) appeared as next better treatments. While treatment of Cow urine proved less effective recorded 8.09 per cent bollworm complex damage and was found to be at par with untreated control (10.11%).

Ten days after spray

Among the different treatments, Dr. PDKV-Entomology formulation showed cumulative bollworm complex damage of 3.97 per cent at ten days after spray (Table 1). This was followed by treatment Brahmasthra extract and Panchpatre extract with 4.15 and 4.60 per cent bollworm complex damage, respectively. However, these treatments were found at par with each other. The treatment of Neem seed extract (5.70%) and Broad-spectrum formulation (5.76%) proved moderately effective in this respect. Whereas, plots treated with Garlic-Chilli extract and Cow urine recorded 6.13 and 8.0 per cent damage in green fruiting bodies, respectively and proved comparatively less effective. The highest bollworm complex damage was recorded in untreated control (10.34%).

Mean

It is evident from the cumulative mean data presented in Table 1 that after three sprays, treatment of Dr. PDKV-Entomology formulation proved effective with minimum bollworm complex damage in green fruiting bodies *i.e.* 4.09 per cent. However, this treatment was found at par with Brahmasthra extract (4.28%) and Panchpatre extract (4.69%). Whereas, Broad-spectrum formulation (5.83%) and Neem seed extract (5.86%) appeared as next better treatments. These were followed by treatment of Garlic-Chilli extract (6.23%) and Cow urine (8.04%) found at par with each other. The maximum per cent bollworm complex damage was recorded in untreated control (10.13%).

The present findings pertaining to effect of various plant extracts against bollworm complex finds support in the work carried out by earlier workers. These plant extracts have been used in present study as one of the components of different organic extracts treatments. Malinga (2012) tested different plant extracts with potential insecticidal properties against cotton bollworms. He found that tobacco was the most promising biological pesticide against American bollworm *(H. armigera)* and spiny bollworm (*E. insulana)* larvae and suggested these plant extracts (particularly from tobacco and garlic) can be used as a cheaper and more environment-friendly alternative to chemical insecticides for the control of bollworms. Moreover, Abro et al. (2011) observed maximum bollworm damage (3.36 larvae/plant) in control and minimum in plots treated with tobacco extract (1.04 larvae/plant). Whereas, the earlier worker Yousef et al. (2018) documented that the toxic effect of the extract against the insect increased with the increase of 70 per cent hydroethanolic extracts of *Nerium olender* (leaves, stems and flowers) against the 1st instar larvae of *P. gossypiella* (Saunders). However, Moustafa et al. (2018) the treatment with cow's urine-dung extract (1: 1) and cow's urine-dung extract: water 1: 4 (v: v) recorded 70.7 and 63.6 per cent reduction in bollworm larvae, respectively. These results indicated that plant extract treatments were more effective on bollworm complexes are in accordance with findings of the present studies.

Effect of organic extracts on seed cotton yield

The data presented in Table 1 regarding seed cotton yield was found statistically significant. However, among the different treatments the plots treated with Dr. PDKV- Entomology formulation recorded highest seed cotton yield of 12.10 q/ha. The next effective treatments were Brahmasthra extract and Panchpatre extract which recorded seed cotton yield of 9.50 and 8.30 q/ha, respectively. Both these treatments were found at par with each other. Whereas, plots treated with Broad-spectrum formulation and Neem seed extract recorded seed cotton yield of 7.80 and 7.10 q/ha, respectively proved moderately effective. While the treatment of Garlic-Chilli extract and Cow urine produced seed cotton yield of 6.20 and 5.50 q/ha. However, both this treatments found statistically equal to untreated control (5.20 q/ha).

The present results regarding recovery of maximum seed cotton yield due to application of different organic extracts are in confirmation with the result obtain by earlier workers like Malinga (2012) who documented that nicotine preparations were reported to be toxic to lepidopterous pests and gave satisfactory control against the american bollworm larvae on cotton moreover, tobacco treatment gave significant higher yields among the botanicals *i.e.* 37.50 q/ha. However, the untreated control yields 28.60 q/ha. Whereas, Rajput et al. (2017) concluded that the reduction in larval population and thereby reduction of open boll damage was higher on application of tobacco extracts as compared to other botanical pesticides. The study suggested that bio-extracts are useful in controlling the pest problem and also helpful in increasing yield. The earlier worker, Zobayer and Hasan (2013) reported that among the botanical extracts tested, neem leaves extract and garlic bulb extracts were outstanding in producing higher yield of okra. In all cases, neem leaf extracts were outstanding in production manner as well as pest management systems.

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Soil Test Crop Response (STCR) based Nutrient Management for Sunflower Oriented Crop Sequence

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Abstract: An investigation was undertaken at Oilseeds Research Unit, Dr. PDKV, Akola, Maharashtra during *Kharif-Rabi* season of 2019-20 to develop a balance and integrated nutrient supply system for sunflower based cropping sequence considering the efficient utilization of residual nutrients along with added fertilizer by the crops grown in sequence. Four cropping systems with sunflower as a component crop are tested with three fertilizer levels. Four cropping systems with three levels of fertilizer 100% RDF, 100% STCR and 50% STCR were tried in split plot design in rabi season. Significantly highest system sunflower equivalent yield (3566 kg ha^{-1}) was recorded in soybean–sunflower cropping system over other cropping systems under study. However, sunflower-chickpea system (3385 kg ha^{-1}) was found at par with soybean–sunflower cropping system and superior over remaining systems. Application of fertilizers as per 100 % STCR noted significantly highest system sunflower equivalent yield (3277 kg ha^{-1}) as compare to other fertilizer levels. The interaction found significant. The interaction of cropping system sunflower-chickpea with 100% STCR recorded highest system equivalent yield (3808 kg ha-1) over rest of the systems.

Sunflower–chickpea cropping system obtained significantly highest system gross returns (Rs. 116780/-ha^{-1}) and system net returns (Rs. 75754/-ha^{-1}) than other cropping systems. The higher B:C ratio (3.08) was recorded with green gram-sunflower cropping system followed by sunflower-chickpea cropping system (2.85). Application of fertilizers as per 100 % STCR gained significantly highest system gross returns (Rs. 108102/- kg ha^{-1}) and system net returns (Rs. 67560/- kg ha-1) over other fertilizer levels. The higher B:C ratio (2.70) was recorded with 100 % STCR.

Key word: Cropping system, STCR, system yield, system GMR, System NMR.

Introduction

Sunflower, the name "Helianthus" is derived from 'Helios' meaning 'sun' and 'anthus' meaning flower. It is the important oilseed crop of the country. Sunflower oil is most popular because of its light colour, bland flavor, high smoke pint and high level of linoleic acid which is good for heart patient. Sunflower seed contains about 48-53 percent edible oil. It can be grown on wide range of soil from sandy loam to black soils. It gives best result when grown under fertile well drain soil. Imbalanced fertilization and/ or inadequate replenishment of native soil nutrient reserves has resulted in the emergence of multinutrient deficiencies, decline in factor productivity of applied nutrients and concomitant reduction in the productivity of several crops including oilseeds in India (Hegde and Sudhakara Babu 2009; Suresh et al. 2013). On an average, only 52.5 kg ha^{-1} nutrients nitrogen, phosphorus and potassium (NPK) are applied in oilseeds as against the 140 kg ha^{-1} for rice and 160 kg ha^{-1} for wheat (Tiwari 2008). The goal of nutrient management is to maximize plant productivity while minimizing environmental consequences. Nutrient management plans document available nutrient sources, production practices and other management practices that influence nutrient availability, crop productivity and environmental consequences. The shortage and high cost fertilizers necessitate that every unit of fertilizer be used judiciously. In view of high location specific nutrient needs and soil test based fertilizer recommendation for specific crop and crop sequences. In india, sunflower is grown over the area of 8.30 lakh hectares with a production and productivity 5.44 lakh tones and 655 per hectare respectively during the year 2012-13 (Anon 2013), thereafter the productivity increased after involvement of sunflower hybrids.

Among the various method of fertilizer recommendation critical value approach, the soil test crop response (STCR), approach for target yield is unique in indicating soil test based fertilizer does and the level of yield that can be achieved with good agronomic practices. (Singh *et al.* 2005). The current blanket fertilizer application (state or region specific) are gross approximation based on the nutrient requirement of individual crops, ignoring the carryover effect of fertilizers to the succeeding crops. Fertilizer use efficiency can be increased by adopting appropriate nutrient management strategies based on the cropping system as a whole, rather than individual crops. Hence, attempt has be made to develop an integrated nutrient supply system for the efficient utilization of residual and cumulative soil nutrient balance along with added fertilizers in the sunflower based cropping system sequence.

Material and Methods

A field experiment was carried out at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *kharif-Rabi season* of 2019-20. Four cropping systems with sunflower as a component crop are tested with three fertilizer levels. Four cropping systems with three levels of fertilizer 100% RDF, 100% STCR and 50% STCR were tried in split plot design in rabi season. Main crop consist of four cropping system viz., C_1: Greengram- Sunflower, C_2: Soybean-Sunflower, C_3: Sunflower- Chickpea, C_4: Sunflower- Rabi Sorghum and sub plot comprises STCR based fertilization viz., F_1 100% RDF, F_2 100% STCR and F_3 50% STCR for rabi season crop replicated trice and laid out in split plot design. Five plants were randomly selected by moving diagonally in the net plot, growth and yield attributes and yield were recorded at harvest. Economics was worked out on the basis of yield, cost of inputs and selling prices of crops at that time

The soil of experimental soil was medium black with clay loam type. The available nutrient status of the soil was low in nitrogen (182 kg ha^{-1}), medium in phosphorus (18.64 kg ha^{-1}), and high in potash (368 kg ha^{-1}). The pH 8.27, EC (dSm^{-1}) 0.34, Organic carbon (g kg^{-1}) 4.6, and Calcium carbonate % 6.95. The sunflower hybrid DRSH-1 was used for this experiment with a seed rate of 5 kg ha^{-1}. The green gram, soybean and sunflower was sown in *kharif* season followed by succeeding crop in rabi viz., sunflower, chickpea and rabi sorghum. The yield targets for sunflower, gram and rabi sorghum were chosen 18 q ha^{-1}, 12 q ha^{-1} and 50 q ha^{-1}.

- Fertilizer prescription equation for yield targeting in **Sunflower**

  $FN = 13.94\ T - 0.61\ SN$ $\qquad FP_2O_5 = 7.18\ T - 6.82\ SP$

  $K_2O = 4.82\ T - 0.12\ SK$

- Fertilizer prescription equation for yield targeting in **Gram**

  $FN = 4.56\ T - 0.18\ SN$ $\qquad FP_2O_5 = 12.51\ T - 7.61\ SP$

  $K_2O = 3.53\ T - 0.05\ SK$

- Fertilizer prescription equation for yield targeting in **Rabi sorghum**

  $FN = 4.7\ T - 0.77\ SN$ $\qquad FP_2O_5 = 2.0\ T - 4.29\ SP$

  $K_2O = 3.35\ T - 0.33\ SK$

Where F and S indicate the fertilizer and soil nutrients respectively (kg ha^{-1}) and T indicates yield target (q/ha)

Results and Discussion

Yield attributes

Different nutrient management practices have a significant effect on yield attributes viz., head diameter, 100 seed weight and volume weight. Among the nutrient management treatments, it was significantly higher (16.9cm, 8.78g and 40.3g/100ml respectively) under STCR approach than RDF and 50% STCR approach. The highest yield contributing characters was highest in sunflower-chickpea cropping system. The results are in accordance with Shanwad U.K et.al. (2015).

Plant height

From the table-1 it was revealed that, in green gram-sunflower system, the plant height of green gram and sunflower was 53.87 cm and 174.44 cm respectively. Whereas, in soybean-sunflower recorded the height of 64.40 cm and 194.89 cm respectively. In the systems with sunflower as *kharif* crop i.e. sunflower-chickpea and sunflower-rabi sorghum, the height of sunflower was 176.96 cm and 171.23cm respectively. While the chickpea and rabi sorghum attended the height of 33 cm and 179.11 cm respectively. The variability of the height is due to the genotypic characters of the different crops in cropping system.

Head diameter

Head diameter of 14.3 cm, 17.2 cm, 14.10 cm and 14.85 cm was found under green gram-sunflower, soybean-sunflower, sunflower – chickpea and sunflower – rabi sorghum respectively.

Number of pods per plant

Under green gram – sunflower, soybean- sunflower, sunflower – chickpea system, green gram, soybean and chickpea produced 13.40, 23.66, 29.9 pods/plant respectively.

Test weight

The test weight of greengram, soybean, sunflower and sunflower was recorded as 3.38 g, 8.70 g, 4.42 g and 3.21 g, respectively.

In case of fertilizer levels, application of 100% STCR recorded highest plant height (150.42 cm), Head diameter (16.9cm), 100 seed weight and volume weight over 50% STCR and 100% RDF.

Yield and Economics

System sunflower equivalent yield: Significantly highest system sunflower equivalent yield (3566 kg ha^{-1}) was recorded in soybean–sunflower cropping system over other cropping systems under study. However, sunflower-chickpea system was found at par with soybean–sunflower cropping system and superior over remaining systems. Application of fertilizers as per 100 % STCR noted significantly highest system sunflower equivalent yield (3277 kg ha^{-1}) as compare to other fertilizer levels. The interaction found significant. The interaction of cropping system sunflower-chickpea with 100% STCR recorded highest system equivalent yield (3808 kg ha$_{-1}$) over rest of the systems. The results are in accordance with Sesha Saila Sree P. *et. al.* (2006) revealed that, among different sunflower based cropping sequences, the sunflower equivalent yield of groundnut sunflower was the highest (1555 kg ha^{-1}) and found at par with setaria-sunflower (1545 kg ha^{-1}) and sunflower – sunflower (1503 kh ha^{-1}). Soil test based nutrient management approach can be an important entry pint activity and also a mechanism to diagnose and manage soil fertility in practical agriculture (Wani, 2008). Soil test based nutrient application also allows judicious and efficient use of nutrient input at the local and regional level (Sahrawat et al. 2010)

Economics of cropping system

Sunflower–chickpea cropping system obtained significantly highest system gross returns (Rs. 116780/-ha-1) and system net returns (Rs. 75754/-ha-1) than other cropping systems. The higher B:C ratio (3.08) was recorded with greengram-sunflower cropping system followed by sunflower-chickpea cropping system (2.85). Application of fertilizers as per 100 % STCR gained significantly highest system gross returns (Rs. 108102 /- kg ha^{-1}) and system net returns (Rs. 67560/- kg ha^{-1}) over other fertilizer levels. The higher B:C ratio (2.70) was recorded with 100 % STCR. These results of economics are in accordance with the result obtained by Sesha Saila Sree P. *et. al.* (2006) wherein, highest gross monitory return was recorded in groundnut-sunflower cropping system in vertisols of scarce rainfall zone of Andra Pranesh.

Per day returns

Highest per day returns (Rs. 598.87) was gained from the sunflower– chickpea cropping system followed by soybean – sunflower (Rs. 499.87) and lowest was obtained from Soybean – sorghum cropping system.

Table 1: Growth and yield and its attributes of kharif and rabi crops as influenced by cropping systems and fertilizer levels. (2019-20)

Treatments	Plant height (cm)		Head diameter (cm)/ no. of pods per plant		100 Seed weight (g)		Volume weight (g/100ml)		Oil / Protein content (%)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Main plot: Cropping System (04)										
C1:Greengram-Sunflower	53.87	174.44	13.40	14.3	3.38	4.96	--	33.5	--	34.9
C2: Soybean-Sunflower	67.40	194.89	23.66	17.2	8.70	5.07	--	31.6	--	32.7
C3:Sunflower- Chickpea	176.96	33.00	14.10	29.9	4.42	19.68	34.12	26.8	38.56	--
C4:Sunflower- Rabi Sorghum	171.23	179.11	14.85	--	4.21	4.03	32.34	64.2	38.28	--
Sub plot: Fertilizer levels (03)										
F1- 100% RDF	--	149.67	--	15.4	--	8.38	--	38.8	--	--
F2 -100 % STCR	--	150.42	--	16.9	--	8.78	--	40.3	--	--
F3- 50 % STCR	--	136.00	--	13.7	--	8.15	--	37.9	--	--

Table 2: Crop equivalent yield, SGMR and SNMR as influenced by cropping system and fertilizer levels.

Treatments	Kharif seed yield (kg ha^{-1})	Kharif Sunflower equivalent seed yield (kg ha^{-1})	Rabi Seed yield (kg ha^{-1})	Rabi Sunflower equivalent seed yield (kg ha^{-1})	System sunflower equivalent yield (kg ha^{-1})	System gross returns ($Rs.ha^{-1}$)	System net returns ($Rs.ha^{-1}$)	System COC (Rs. ha^{-1})	System B:C ratio
Main plot: Cropping System (04)									
C1: Greengram-Sunflower	941	1419	1642	1642	3061	103842	70144	33699	3.08
C2: Soybean-Sunflower	1337	1744	1822	1822	3566	104972	58844	46128	2.27
C3: Sunflower-Chickpea	1065	1066	1778	2319	3385	116780	75754	41026	2.85
C4: Sunflower-Rabi Sorghum	1124	1125	1307	834	1958	67544	28792	38753	1.74
SE (m) ±	--	--	47.32	54.47	68.34	1879	1879	--	--
CD @ 5 %	--	--	163.76	188.48	236.49	6502	6502	--	--
CV (%)			8.67	9.88	6.85	5.74	9.66	--	--
B) Sub plot : Fertilizer (kg ha-1) (3)									
F1- 100% RDF	--	1339	1662	1664	3002	98613	58052	40561	2.45
F2 -100 % STCR	--	1339	1914	1939	3277	108102	67560	40542	2.70
F3- 50 % STCR	--	1339	1336	1360	2699	88140	49539	38601	2.31
SE (m) ±	--	--	32.1	32.5	32.5	1119.6	1119.6	--	--
CD @ 5 %	--	--	96.4	97.29	97.29	3356.6	3356.6	--	--
CV (%)									
Interaction (C x F)									
SE (m) ±	--	--	64.3	64.9	64.9	2239	2239	--	--
CD @5 %	--	--	NS	194.6	194.6	6713	6713	--	--

Table 3 : CXF Interaction of system sunflower equivalent seed yield (kg ha-1) as affected by different treatments

C/F	100% RDF	100 % STCR	50 % STCR
C1: Greengram- Sunflower	2980	3442	2762
C2: Soybean- Sunflower	3592	3783	3323
C3: Sunflower- Chickpea	3376	**3808**	2972
C4: Sunflower- Rabi Sorghum	2062	2076	1737
SEm± : 64.9 CD at 5% : 194.6			

Table 4 : Per day returns as influenced by various cropping systems.

Sr. No.	Cropping system	Per day returns (Rs.)
01	C1: Green gram- Sunflower	570.56
02	C2: Soybean- Sunflower	499.87
03	C3: Sunflower- Chickpea	598.87
04	C4: Sunflower- Rabi Sorghum	312.70

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Performance of Sorghum Hybrid Varietal Lines Against Grain Mold at Vidarbha

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Abstract: Grain mold is the major thrust among the various reasons for reduction of sorghum production. The grain mold is the pathogenic and saprophytic fungi which are involved in grain mold complex of sorghum. The different sorghum lines respond variedly against the grain mold causing entities. Grain mold field grade within the lines were significant. Significantly minimum field grade was noted for grain mold in checks B 58586 and Kekri local. Only sorghum line SPV-2573 and SPV-2568 had at par field grade. Similar was the situation for grain mold threshed grade. The sorghum line B 58586 proved promising expressing significantly low threshed grade.

Key words: grain mold, sorghum varieties, pathogenic and saprophytic fungi

Introduction

Grain mold is a major disease of kharif season sorghum and is common in many countries in Asia, Africa, North America, and South America. (Das IK and Padmaja 2016). The disease is severe in Asia and Africa where white grain sorghum are grown widely. Improved short- and medium-duration sorghum cultivars that mature during the kharif season in humid, tropical, and subtropical climates suffer more. Late-maturing photoperiod sensitive sorghums generally escape grain mold as they flower and fill grain during dry weather. Colored grain sorghum which is grown for feed purpose in the United States, Mexico, Argentina, and Australia suffers relatively less from this disease. The disease is most severe in India where the high yielding white grain hybrids are grown during kharif season.

In India, sorghum is an important staple food for people living in the dry tracts of the country. It has also gained importance as feed, fodder and biofuel crop. It is grown during both rainy (kharif) and winter (rabi) seasons. During seventies sorghum was the second most widely grown

Karnataka Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Rajasthan and Gujarat. With the change in climate, cropping pattern, introduction of high yielding hybrids and varieties, the disease scenario has also changed and once minor disease has become major later. Grain mold of kharif sorghum is one such disease, which has changed its significance over time. Gradually, it has become number one disease of kharif sorghum for its devastating effects on yield and quality. Gravity of the situation was so that all the organizations involved in research and development of kharif sorghum in India allocated major share of their resources to tackle the problem. Regional station of Indian Agricultural Research Institute (IARI) at Hyderabad, which was subsequently developed to a full fledge institutes as National Research Center for Sorghum, the State Agricultural Universities (SAUs) in the state of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Madhya Pradesh, and the International Crop Research Institute for Semi-arid Tropics (ICRISAT) Patancheru, were intensely involved on grain mold research and developed and released many grain mold tolerant high yielding hybrids and varieties over time. This book portrays the journey of grain mold research from its inception to the present time with emphasis on India.

Few fungi infect sorghum spikelet tissues during early stages of grain development and seed borne, these are *viz., Curvularia lunata, Drechslera tetramera, Bipolaris sorghicola, Drechslera longirostreta, Fusarium moniliforme, Alternaria alternata, Aspergillus niger*, (Islam et al. 2009., Panchal and Dhale 2011..). In Vidarbha region, the most common grain mold fungi in relative order of frequencies are *C. lunata* (40-60%), *F. moniliforme* (15-20%), *F. pallidoroseum, Drechslera* spp., *Phoma sorghina, Alternaria* spp. and *Aspergillus* spp. (5-30%). *C. lunata* and *F. moniliforme* secrete amylases, celluloses and pectinases resulting in disintegration of endosperm and germ tissue.

Materials and Methods

The Ten entries along with 11 checks were studied for this experiment in three replication. The observations were taken at panicle grain mold rating % at physiological maturity (PGMR) after flowering stage at cobs formation. Threshed grain mold rating (%) (TGMR) was observed after threshing cobs; the grain mold was recorded on the threshed seed.

Results and Discussion

The PGMR were related in progressive scale of 1 to 9 and TGMR of each genotype after harvesting, threshing and drying the grains, all the entries recorded TGMR in between 19.8-78.5% including checks (Table 1). Minimum TGMR i.e. 19.8% was observed in B-58586 (RC) the maximum TGMR recorded (78.5%) in BulkY (SC). Regarding per cent germination out of 19 entries one entry recorded more than 75% germination (Table 1). Maximum germination in B-58586 (RC) (76%) and minimum recorded in (15%) BulkY (SC).Infection due to *F. moniliforme* was recorded in the range of 17-43% minimum in QL 3(C) (17%). For *C. lunata* it was in the range of 12-36% (Table 1), minimum (12%) in AKSV181 (LC); however, for infection due to other fungi the range was 21-62% with minimum infection 21% recorded in Kekri Local(RC). Maximum infection of *F. moniliforme* (43%) recorded in BulkY (SC). *C. lunata* (36%) in BulkY (SC) and other fungi (62%) recorded in BulkY (SC).As regard 100 grain test weight, it was recorded in the range of 1.53 to 3.76 g with maximum of 3.76 g was recorded in SPV 2568.

Table 1: Reaction of sorghum entries against major diseases of sorghum in *kharif* 2019

Sr. No.	Entries	DTF	P.G.M.R %	TGMR %	% Germination	% Associated fungi			100 seed Wt (g)
						FM	CL	Other	
1	SPV 2504	76	8.0	31.5	59	24	21	28	2.77
2	SPV 2510	75	9.7	38.7	51	26	22	30	2.65
3	SPV 2566	75	8.3	30.5	50	21	17	32	2.31
4	SPV 2567	71	8.0	32.1	42	25	16	26	2.49
5	SPV 2568	69	6.7	30.0	54	19	13	36	3.76
6	SPV 2569	68	9.3	35.5	44	21	20	34	3.08
7	SPV 2570	76	6.3	31.0	61	30	19	30	3.03
8	SPV 2571	72	12.0	32.2	56	30	27	35	2.31
9	SPV 2573	79	6.7	35.2	52	18	26	32	3.20
10	CSV 31	77	9.0	35.2	44	20	26	40	2.82
11	CSV 27	81	10.0	30.0	64	23	19	28	2.53
12	CSV 20	73	10.0	43.5	44	28	24	36	3.05
13	CSV 17	63	9.0	30.6	55	20	18	29	1.95
14	AKSV-181(LC)	78	10.0	35.8	69	18	12	29	2.71
15	B 58586(RC)	68	3.7	19.8	76	21	16	26	1.53
16	Kekri Local (RC)	79	7.9	31.0	68	32	15	21	2.51
17	BulkY(SC)	62	18.3	78.5	15	43	36	62	1.98
18	QL 3 (SC)	76	15.3	32.7	46	17	16	33	1.95
19	Pant Chari 5(RC)	79	5.7	31.0	61	22	24	30	2.46

Where, DTF – Day's to 50% flowering : PGMR Panicle grain mold rating % at physiological maturity TGMR – Threshed grain mold rating (%) ; (FM – *Fusarium moniliforme* CL – *Curvularia lunata*;

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Influence of Intercropping in Bt Cotton on Beneficial Insects

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Abstract: The research experiment on 'Influence of intercropping in Bt cotton on beneficial insects' was conducted during *Kharif* season of 2017-18 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Randomized Block Design with three replication and eleven different treatments of intercropping systems consisting of Cotton + Cowpea (1:1), Cotton + Cowpea (1:2), Cotton + Soybean (1:1), Cotton + Soybean (1:2), Cotton + Blackgram (1:1), Cotton + Blackgram (1:2), Cotton+ Greengram (1:1),Cotton+ Greengram (1:2), Cotton+ Clusterbean (1:1) and Cotton+ Clusterbean (1:2) along with a treatment of sole cotton. The treatments with Cotton + Cowpea (1:2) recorded highest population of LBB i.e.2.24 LBB/plant which was at par with Cotton + Clusterbean (1:2) with 2.07 LBB/plant. Among the intercrops Cotton+ Cowpea (1:2) recorded maximum population of Chrysopa i.e.1.53 Chrysopa/plant and found statistically superior over all other treatments. However, maximum number of spiders were observed in cotton intercropped with cowpea (1:2) i.e.2.22 spiders/plant. Among intercropping systems Cotton+ Greengram (1:1), Cotton+ Greengram (1:2) and Cotton+Blackgram (1:1) proved to be the most productive intercropping system in terms of seed cotton equivalent yield. The research findings indicated that intercropping in Bt cotton provided an opportunity for natural enemies of the pests to flourish, resulting in poison free product to the farmers.

Key words: Bt, cotton, intercropping, beneficial insects.

Introduction

Cotton (*Gossypium hirsutum L.*) is one of the most important cash and fiber crop in India popularly known as "White Gold" or "King of Fiber". Cotton has become first important *Kharif* crop in India especially in Vidarbha region of Maharashtra. It also playing a key role in synergizing the economy of Vidarbha. There are many causes of the low productivity of cotton crop, the insect pests is one of the major cause. Cotton crop requires an intensive use of pesticides in order to control the various pests that cause extensive damage. Over the past 40 years many pests have developed resistance against the pesticides (Reddy et al.2009). The increasing problems due to continued usage of pesticides and failure of any individual components to check the pest population in cotton have made the adoption of integrated pest management.

Intercropping plays a pivotal role as one of the important components of integrated pest management in diverting the pests from main crop to another crop and reducing the loss of the main crop as well as offer excellent opportunities for crop growth by providing better niches to biotic agents regulating pest population (Shelton and Perez,2006). It also help in manipulation of the environment in such a way as to render it unfavorable for crop pests but favorable to its natural enemies (Godhani et al.2009). Hence the present study was undertaken to evaluate the effect of different intercrops on the population of natural enemies of cotton crop and to evolve the eco-friendly cropping system in order to manage the pest and to increase the population of natural enemies.

Material and Methods

The present investigation entitled "Influence of intercropping in *Bt* cotton on beneficial insects" was carried out on the field of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2017-18. The experiment was laid out in Randomized Block Design with three replication and eleven treatments. The different intercropping systems included in the study were Cotton +Cowpea (1:1), Cotton + Cowpea (1:2), Cotton + Soybean (1:1), Cotton + Soybean (1:2), Cotton + Blackgram (1:1), Cotton + Blackgram (1:2), Cotton + Greengram (1:1), Cotton + Greengram (1:2),Cotton+ Clusterbean (1:1), Cotton+ Clusterbean (1:2) along with sole cotton with an object to assess the effect of different cotton based intercropping systems on beneficial insects and to work out the productivity of the intercropping system in terms of seed cotton equivalent yield.

The observations on the beneficial insects viz; lady bird beetle, Chrysopa and spider were recorded on randomly selected five plants per plot on whole plant basis at 15 days interval from 30 days after germination till harvesting of intercrops. Moreover, seed cotton yield obtained from all pickings and yield of intercrops from net plot was recorded. Finally the seed cotton equivalent yield in q/ha was worked out.

$$\text{Seed Cotton equivalent yield (q/ha)} = \frac{\text{Yield of intercrop (q/ha)} \times \text{price of intercrop (Rs/q)}}{\text{Price of cotton(Rs/q)}} + \text{Seed cotton yield (q/ha)}$$

Result and discussion

Effect of different intercropping systems on population of Ladybird beetle

The observation presented in Table 1 showed that the population of ladybird beetle (LBB) was observed in all the treatments of intercrops during 33rd M.W. to 42nd M.W. i.e. from 13th August to 21th October. However, the treatments with Cotton + Cowpea (1:2) recorded highest population of LBB i.e.2.24 LBB/plant at par with Cotton + Clusterbean (1:2) (2.07 LBB/plant). The Cotton+ Soybean (1:2) recorded 1.77 LBB/plant. The next effective intercrops were Cotton+ Blackgram (1:2), Cotton+ Greengram (1:2), Cotton +Cowpea (1:1), Cotton+ Clusterbean (1:1), Cotton+Soybean (1:1) and Cotton+ Greengram (1:1) recording the population of LBB within the range of 1.27 to1.54 LBB/plant. Whereas, the cotton intercropped with blackgram (1:1) recorded 1.21 LBB/plant. The lowest population of LBB was recorded in sole cotton i.e.0.98 LBB/plant.

The present findings on the population of LBB are in the accordance with the result obtained by earlier worker Natarajan and Seshadri (1998) who studied the effect of intercropping in cotton on population of natural enemies reported that cotton+ cowpea and cotton+ soybean haboured higher population of LBB as compared to sole cotton. Similar results were also reported by Sharma et al. (2009) that interplant cowpea acted as source of predators due to diverse microhabitats, greater availability of food sources, all of which encouraged the colonization and build up of natural enemies, compared with cotton monoculture having lesser biodiversity.

Effect of different intercropping systems on population of Chrysopa (*Chrysoperla carnea*)

The data (Table 2) revealed that the population of Chrysopa was observed in all the treatments of intercrops during 34th M.W to 43rd M.W. i.e. from 20th August to 28th October. Among the intercrops Cotton+ Cowpea (1:2) recorded maximum population of Chrysopa i.e.1.53 Chrysopa/plant and found statistically superior over all other treatments. The next effective intercrops which recorded higher number of Chrysopa were Cotton+ Clusterbean (1:2), Cotton+ Soybean (1:2) and Cotton+ Clusterbean (1:1) which recorded 1.36, 1.27 and 1.14 Chrysopa/plant, respectively. The intercropping systems were *viz.*, Cotton+ Cowpea (1:1), Cotton+ Blackgram (1:2), Cotton+ Greengram(1:2) and Cotton+ Soybean (1:1) recorded the population of Chrysopa within the range of 0.97 to 1.09 Chrysopa/plant and found at par with each other. The intercropping systems Cotton+ Blackgram (1:1) and Cotton+ Greengram (1:1) recorded comparatively lower population i.e.0.95 and 0.84 Chrysopa/plant. Whereas, the sole cotton recorded least population of Chrysopa i.e.0.74 Chrysopa/plant.

The present findings regarding higher population of Chrysopa in intercropping system is in accordance with Swaminathan et al.(1999) who reported that among six intercrops evaluated, cotton intercropped with cowpea in paired row system was favourable for the conservation of *Chrysoperla carnea*. Cotton alone was comparatively less favourable to the multiplication of *Chrysoperla carnea* which correspondingly recorded more population of insect pests. Similar results were also reported by Hegde et al. (2003) that the average population of *Chrysoperla carnea* and spider were high in cotton intercropped with cowpea.

Effect of different intercropping systems on population of Spider

The data depicted in Table 3 revealed that the population of spiders was active in all the treatments of intercrops during 34th M.W. to 43rd M.W. i.e. from 20th August to 28th October. However, maximum number of spiders were observed in cotton intercropped with cowpea (1:2) i.e. 2.22 spiders/plant. Whereas, Cotton + Clusterbean (1:2), Cotton+ Soybean (1:2) and Cotton+ Cowpea (1:1) recorded 1.94 ,1.73 and 1.60 spiders/plant, respectively. The next effective intercropping systems were Cotton+ Greengram (1:2), Cotton+ Clusterbean(1:1),Cotton+ Blackgram (1:2),Cotton+ Soybean(1:1), Cotton+ Greengram (1:1) and Cotton+ Blackgram(1:1) recorded population of spiders within the range of 1.13 to 1.46 spiders/plant. Whereas, the sole cotton recorded least number of spiders i.e. 0.94 spiders/plant.

Enhancement of various arthropod natural enemies of cotton pests in intercropping systems might be due to the plant diversification. The present result on the higher population of spiders recorded in intercropping system find supports in the work carried out by earlier worker Roy and Sarkar (2017) reported that ethanolic extract present in flower petals of clusterbean attracts large number of natural enemies. However, Patel *et al.* (2012) reported significantly higher population of predatory spiders registered in cotton + cowpea intercropping system. Moreover, Mohanasundaram *et al.* (2012) reported largest population of spiders on okra intercropped with clusterbean. Similarly, Rajput and Daware (2002) reported that intercropping of maize, sorghum or cowpea in cotton increased the population of arthropod predators in main crop.

Effect of different intercropping system on seed cotton equivalent yield

The total productivity of the system indicated in terms of seed cotton equivalent yield in (Table 4) revealed that, Cotton+ Greengram (1:1), Cotton+ Greengram (1:2) and Cotton+ Blackgram (1:1) were the most productive intercroppings in terms of seed cotton equivalent yield i.e.18.22,17.74 and 17.21 q/ha, respectively. The other intercropping systems i.e. Cotton+ Blackgram (1:2), Cotton+ Clusterbean (1:1),Cotton+ Soybean (1:1),Cotton+ Clusterbean (1:2),Cotton+ Cowpea(1:1),Cotton+ Soybean(1:2) and Cotton+ Cowpea (1:2) showed productivity in terms of seed cotton equivalent yield in descending order i.e.16.30, 15.88, 14.87, 14.65, 14.52, 14.02 and 13.32 q/ha, respectively. Whereas, sole cotton was lowest productive in terms of seed cotton equivalent yield i.e.12.83 q/ha.

The present findings pertaining to seed cotton equivalent yield are in accordance with the earlier worker Singh et al. (2017) who reported that seed cotton equivalent yield was increased due to different intercrops over the sole crop of cotton. Similar results reported by Asewar et al.(2008) who recorded significantly higher seed cotton equivalent yield in Cotton+ Greengram over rest of the intercrops. The increased seed cotton equivalent yield in different intercrops over the sole crop of cotton was attributed to better productivity of cotton, intercrops and their remunerative market prices.

Conclusion

Intercropping plays a pivotal role as one of the important components of integrated pest management offers excellent opportunities for crop growth by providing better niches to biotic agents regulating pest population. Thus, the results of the present studies are helpful in reducing the insecticidal load from crop and ultimately providing opportunity for beneficial insects to flourish, resulting in better economic returns and poison free product.

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Intercropping Innovation in Cane Plant Around Central Narmada Valley of Madhya Pradesh

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Abstract Sugarcane intercropping experiment performed in the year 2019-20 at research farm of Sugarcane Research Station Bohani, Narsinghpur, in randomized block design with three replications and four cropping systems including sugarcane sole plot, Sugarcane +coriander, Sugarcane +peas and Sugarcane +garlic. Data was analysed simply on yield basis where it differs significantly. The results showed that solely when cane crop was grown gives maximum yield (78.1 tonnes hec^{-1}) as compared to cane yield of other three systems of intercropping that is Sugarcane +garlic (77.6 tonnes hec^{-1}), followed by Sugarcane + coriander (75.3 tonnes hec^{-1}) and Sugarcane + peas (74.5 tonnes hec^{-1}). Whereas considering yield and benefits obtained from intercropping, Sugarcane + garlic system gives maximum returns (84.1) in terms of additional yield along with the cane followed by Sugarcane +peas (81.7) and Sugarcane +coriander (78.7). This research suggested that for farmers growing sugarcane on small scale, intercropping become a beneficial and continuous source of income at initial stages of growth sugarcane. This may help in doubling the source of income. Whereas for commercial growers intercropping is not much beneficial as sole planting of cane crop.

Keywords: sugarcane, intercropping, doubling income

Introduction

Present study was conducted to monitor the benefits gained by growing different types of intercrop along with the sugarcane crop. The farmers of Central Narmada Valley of Madhya Pradesh including villages of Narsinghpur district were major cash crop sugarcane was grown by the farmers for various purposes like sugar, *gud*, alchohal etc. for obtaining these byproducts farmers had to wait for long duration of 18 month as the crop is annual crop, in order to utilize such vacant period left between the growth stages of cane crops and to double the income from the same piece of land in the same year farmers had to plan intercropping.

Sugarcane planted in the month October- November is more suitable for intercropping, as low temperature during winters slows down the growth of sugarcane plants and slow growth rate during first 2-3 month of its growth period were suitable for short duration winter vegetables and other crops like wheat, chickpea planted in the same season.

Intercropping has its own role in doubling the income of the farmers. Utilizing intercropping within 3 - 5 months from planting the cane, farmers should be able to produce optimum yields of main crop and intercrops by providing the recommended dose of fertilizer for both crop to be planted in the cane inter rows and main crop sugarcane.

Different benefits of intercropping include symbiotic nitrogen fixation (by legume crops), weed control, increased level of organic matter and low water infiltration rates, and soil cover (Garside and Bell, 2007). Intercropping has been used fruitfully for many years in low input cropping systems across the world (Anil et al., 1998). Number of benefits, obtained such as increased yield (Dhima et al., 2007) and land use efficiency within cropping systems, (Lithourgidis et al., 2006), enhancing light, soil conservation improvement (Anil et al., 1998), method of control for weeds, insects and/or diseases (Willey, 1979; Vasilakoglou et al., 2008) and water and nutrient use (Lithourgidis et al., 2008), have been observed. Use of leguminous crops in between the rows of main helps naturally to increase the availability of soil nitrogen, this leads to reduction in use of chemical fertilisers (Tosti and Guiducci, 2010).

Material and Methods

The field experiment was conducted at Sugarcane Research Station, Bohani, Narsinghpur in the year 2018-19. For the entire duration of crop growth the agro climatic variables were noted as shown in the table. Four cropping systems (sole sugarcane, sugarcane-corriander, sugarcane-peas and sugarcane-garlic) had been under taken. Cane crop was intercropped with one row of alternative crop. The rows are 1.2 m apart. There was a 1 m gap between each plot, in each plot one row of cane were planted with one row of other crop. Plots were arranged in a randomised complete block design with three replicates of each treatment. Cane was planted double stick and cut into 2-3 budded setts before covering.

Table 1.1: Mean yield of main crop and intercrop in sugarcane based cropping system.

Cropping system	Mean yield of main crop (tonnes hec^{-1})	Mean yield Intercrop (tonnes hec^{-1})	Total yeild (tonnes hec^{-1})
Sugarcane sole crop	78.1	-	78.1
Sugarcane +corriander	75.3	3.4	78.7
Sugarcane +peas	74.5	7.2	81.7
Sugarcane +garlic	77.6	6.5	84.1

Results

Based on the results obtained, intercropping of sugarcane with coriander, peas, and garlic produced average cane yield (75.36-77.6 t ha^{-1}) similar to yield of sole sugarcane plot (78.1 t ha^{-1}) and intercrop yield of 3.4 t ha^{-1} for corriander, 7.2 t ha^{-1} for peas and 6.5 t ha^{-1} for garlic. This appears to be an economically viable option for the growers, even when they are taking sugarcane crop solely.

In the four scenarios studied, lower cane yields (table 1.1) were assigned to the cane-only. Whereas highest yield obtained by sugarcane +garlic that is 84.1 tonnes from a hectare followed by Sugarcane+peas that is 81.7 tonnes per hectare and Sugarcane +coriander 78.7 tonnes per hectare. Where excluding the yield if intercrop and taking only cane crop sugarcane solely gives the highest yield followed by Sugarcane+garlic, Sugarcane +coriander and Sugarcane+peas. This suggested that for commercial growers intercropping was not a feasible system and for the normal growers intercropping is more beneficial than sole crop. Parsons et al. (1999, 2003) and (Ramouthar PV et al 2013) reported similar results of planting vegetables between sugarcane rows to advance the land use efficiency and profitability and his studies also showed reduced cane yields in the cane + vegetable plots compared to cane-only plots, intercropping proved more profitable where the correct management strategies were adhered to. Considering intercropping offers some benefits, for commercial growers on a large scale. Intercropping leads to extra field operations such as planting of seeds and cutting of intercrop in between the rows of sugarcane. It must be emphasised, then, that intercropping, on the whole, is a much more management intensive operation than growing sugarcane alone. Analyzing the yield of cane crop there is a significant reduction in cane yield in only one out of the three crops harvested, the general tendency was towards a lesser yield in the intercropped systems as compared to the sole sugarcane crop. It can be considered that the success of an intercrop depends on the competitive difference between the intercrops. To grow intercrop with sugarcane and to get maximum sugarcane yields, the selection of less competitive intercrop than sugarcane should be taken into consideration.

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Effect of Temperature and Relative Humidity on Conidial Germination of Post-harvest Pathogens of Nagpur Mandarin

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Abstract: The experiment was conducted to see the effect of temperature and relative humidity on the conidial germinations of post-harvest pathogens in Nagpur mandarin. Maximum conidial germination of *Colletotrichum gloeosporioides* (73.19%), *Geotrichum candidum* (95.17%), *Penicillium digitatum* (93.86%), and *Trichoderma viride* (73.32%) was recorded at 25 °C temperature after 72 hrs. However, lowest conidial germination of post-harvest pathogens was observed at 20°C temperature after 72 hrs. *viz.*, *Colletotrichum gloeosporioides* (53.12%), *Geotrichum candidum* (82.67%), *Penicillium digitatum* (79.22%), *Aspergillus niger* (32.19%) and *Trichoderma viride* (42.75%) respectively. Highest conidial germination were obtained at 90 per cent relative humidity of different pathogens *viz.*,*Colletotrichum gloeosporioides* (89.17%), *Geotrichum candidum* (93.18%), *Penicillium digitatum* (91.36%), *Aspergillus niger* (71.40%) and *Trichoderma viride* (73.32%) after 72 hrs. respectively,whereas, minimum conidial germination was observed at 70 per cent relative humidity after 72 hrs. *viz.*, *Colletotrichum gloeosporioides* (58.24%), *Geotrichum candidum* (81.24%), *Penicillium digitatum* (78.21%), *Aspergillus niger* (41.88%) and *Trichoderma viride* (56.90%) respectively.

Keywords: Mandarin, post-harvest, pathogens, conidial germination

Introduction

Nagpur mandarin (*Citrus sinensis*) is an important fruit occupying significant place among the citrus group. The average yield of citrus fruits in India is alarmingly low (10.1 t/ha) compared to other developed countries like Brazil, USA, China, Mexico and Spain (30-40 t/ha). In India, area under citrus crop was 428.31 thousand ha and production were 5101.21 thousand tons and in Maharashtra state area under this crop was 107 thousand ha and production were 798 thousand tons (Anonymous 2018). Contribution of the citrus industry to the world economy is enormous, and it provides jobs to millions of people around the world in harvesting, handling, transportation, storage and marketing operations. Due to their higher water content and nutrient composition, citrus fruit is very susceptible to infection by microbial pathogens during the period between harvest and consumption (Tripathi and Dubey 2003). Prakash and Srivastava (1987) observed that pathogen's growth is optimum at 25°C and ceases beyond 35°C.Relative humidity is another major factor in determining the growth, conidial germination and disease development Temperature range between 20- 30°C was optimum for the growth and sporulation of *Colletotrichum gloeosporioides* on mango (Davis *et al.*, 1987).

Each pathogen has got its own cardinal temperature and understanding the temperature requirement of the pathogen will help to standardize the management strategies. Postharvest diseases cause significant economic losses for the citrus industry during storage, transport and marketing (Naqvi, 2004 and Solaimani *et al.*, 2009). The post-harvest handling losses of citrus fruits are 5-10% in most developed countries and 25-30 % in developing countries (Maini and Ladaniya, 1999). Considering the intensity of the disease, the present experiment was undertaken to find out the effect of temperature on sporulation of relative humidity on sporulation of post-harvest pathogens of Nagpur mandarin.

Material and Methods

In order to isolate the fungal pathogens, bits of infected skin of fruits along with adjoining healthy area were surface sterilized by dipping in mercury chlorite solution (0.1%) for 1-2 minute followed by three washings with sterilized distilled water and transferred to sterilized Petri dishes containing potato dextrose agar (PDA) medium. The inoculated Petri dishes were incubated at 25±1°C in BOD incubator.

Pathogen was grown on PDA on 7th day the aerial growth of the colony was scraped and suspended in sterile distilled water and spore suspension was prepared. A drop of spore was placed on coverslip and inverted on cavity slide. The edges of coverslip were sealed with vaseline to avoid evaporation. The emergence of germ tube was considered as positive germination.The spores were scored as germinated if the germ tube length was equal or exceed that of the spore length (Suprapta *et al.*, 1997). The slides were incubated at different temperature20°C, 25°C and 30°C. Total number of spores and germinated spores were counted at ten

(10 x) microscopic fields at an interval of 24 hrs, 48 hrs and 72 hrs. The inhibition of conidial germination was calculated in each treatment.

The slides were incubated at relative humidityregimes 70%, 80% and 90%. Total number of spores and germinated spores were counted at ten (10 x) microscopic fields at an interval of 24 hrs, 48 hrs and 72 hrs. The inhibition of conidial germination was calculated in each treatment.

Results and Discussion

The experiment was conducted to see the effect of temperature on the conidial germination of post-harvest pathogens in Nagpur mandarin.

Table 1: Effect of temperature on conidial germination of post-harvest pathogens in Nagpur mandarin

Cultures	Temp.	Conidial germination 24 hrs	48 hrs	72 hrs
		Av. germination	Av. germination	Av. germination
Colletotrichum gloeosporioides				
	20^0C	38.28	48.74	53.12
	25^0C	51.27	65.18	73.39
	30^0C	43.26	54.48	63.46
Geotrichum candidum				
	20^0C	63.44	70.22	82.67
	25^0C	77.61	85.96	95.17
	30^0C	75.13	83.58	93.49
Penicillium digitatum				
	20^0C	62.51	68.36	79.22
	25^0C	76.44	84.71	93.86
	30^0C	59.93	67.38	79.23
Aspergillus niger				
	20^0C	13.52	21.98	32.19
	25^0C	32.09	45.06	56.72
	30^0C	26.15	39.07	57.03
Trichoderma viride				
	20^0C	19.62	29.35	42.75
	25^0C	45.79	57.98	67.72
	30^0C	33.91	40.50	52.60

Data presented in Table 1 revealed that 25^0C was the best temperature for the maximum conidial germination of post-harvest pathogens of Nagpur mandarin. The temperature ranges were taken for conidial germination at 20^0C, 25^0C and 30^0C at 24 hrs, 48 hrs and 72 hrs. Maximum conidial germination of *Colletotrichum gloeosporioides* (73.19%), *Geotrichum candidum* (95.17%), *Penicillium digitatum* (93.86%), and *Trichoderma viride* (73.32%) was recorded at 25 ^{0}C temperature after 72 hrs. Whereas, maximum conidial germination of *Aspergillus niger* was found (57.03%) at 30^0Cafter 72 hrs. Lowest conidial germination of pathogens were observed at 20^0C temperature after 72 hrs. *viz*., *Colletotrichum gloeosporioides* (53.12%), *Geotrichum candidum* (82.67%), *Penicillium digitatum* (79.22%), *Aspergillus niger* (32.19%) and *Trichoderma viride* (42.75%) respectively. These results are in conformity with the previous reports of the*Alternaria* rot,*Penicillium* mold rots and *Aspergillus* black mold rot of citrus caused by *Alternaria alternata, Penicillium digitatum, P. italicum and Aspergillus niger*, respectively have been reported to develop more rapidly at temperature 15-35, 20-25 and 30-35^0C, respectively (Agarwal and Hasija, 1967 and Bhargava, 1972). Pathak (1980) reported that temperature ranges from 20-35^0C to be optimum for the rapid development of fruit rots of citrus. Udhayakumar (2018) reported that 25^0Cwas the conducive temperature for conidial germination (69.00%) of *Colletotrichum gloeosporioides* of mango. Temperature affects almost every function of fungi, including growth, spore germination and reproduction. Temperature plays an important role in reducing physiological deterioration and disease development. Leharwan *et al.* (2018) found that 25°C was the favorable temperature for conidial germination (%) of *Colletotrichum gloeosporioides* in mango.

Highest conidial germination were obtained at 90 per cent relative humidity of different pathogens of Nagpur mandarin *viz.*,*Colletotrichum gloeosporioides* (89.17%), *Geotrichum candidum* (93.18%), *Penicillium digitatum* (91.36%), *Aspergillus niger* (71.40%) and *Trichoderma viride* (73.32%) after 72 hrs. respectively,whereas, minimum conidial germination was observed at 70 per cent relative humidity after 72 hrs. *viz.*, *Colletotrichum gloeosporioides* (58.24%), *Geotrichum candidum* (81.24%), *Penicillium digitatum* (78.21%), *Aspergillus niger* (41.88%) and *Trichoderma viride* (56.90%) respectively.

Godara (1994) reported that severity of *Penicillium* and *Botryodiplodia* rot of sweet orange caused by *Penicillium italicum* and *Botryodiplodia theobromae*, respectively was found highest at 100 per cent and lowest at 40 per cent relative humidity in orange.Prakash (1996) found that relative humidity above 95 percent for 12 hrs is essential for infection and development of *Colletotrichum gloeosporioides* on mango. Infection progress faster in wounded tissues and in ripe fruits. Pérez *et al.* (1990) observed that temperature between 25 and 30°C was opt. for *Trichoderma viride* growth, sporulation and conidial germination of mandarin on PDA. The highest rate of growth at 24 h was obtained at 80-100% relative humidity (RH), the max. sporulation at 100% RH and the max. conidial germination at 80-85% RH. Imatiaj *et al.* (2007) reported that the highest conidial germination of *Colletotrichum falcatum* was 81% at pH 7 and 73% at RH 95% and 70% at 25°C. Udhayakumar (2018) reported that 100 per cent relative humidity was found most effective for highest conidial germination (69.00%) of *Colletotrichum gloeosporioides* in mango.

Table 2: Effect of relative humidity on conidial germination of post-harvest pathogens of Nagpur mandarin

Cultures	Relative humidity (%)	Conidial germination		
		24 hrs	48 hrs	72 hrs
		Av. germination	Av. germination	Av. germination
Colletotrichum gloeosporioides				
	70	39.93	49.92	58.24
	80	50.12	58.34	69.05
	90	74.45	83.33	89.17
Geotrichum candidum				
	70	63.15	69.75	81.24
	80	69.43	78.76	84.37
	90	76.48	83.72	93.18
Penicillium digitatum				
	70	61.63	67.89	78.21
	80	67.26	76.86	83.67
	90	75.68	82.97	91.36
Aspergillus niger				
	70	20.82	29.71	41.88
	80	35.63	51.85	60.28
	90	40.15	56.71	71.40
Trichoderma viride				
	70	31.75	44.28	56.90
	80	40.09	52.30	62.21
	90	48.11	62.48	73.32

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Effect of Integrated Nutrient Management on Growth and Productivity of Hybrid Maize and its Residual Effect on Toria, and System Economics in Maize-toria Cropping Sequence in Odisha

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Abstract: A field experiment was conducted during *kharif* and *rabi* 2017 and 2018 at research farm of Regional Research & Technology Transfer Sub Station, Kirei, Sundergarh, OUAT of Odisha to find out most efficient and economic combination of different organic and inorganic sources of nutrients to increase the productivity of maize and its residual effect on succeeding toria in maize-toria cropping sequence without deteriorating the soil qualities. Integrated application of 75% RDFN + 25% N by vermicompost resulted the highest maize grain yield of 6.79 tonnes ha^{-1} which was 128% higher over the control and 16.5% over application of 100% RDF. The different nutrient management practices administered to the hybrid maize had significant residual effect on the succeeding toria crop. The conjunctive application of 50% RDFN + 50% N by VC to maize had the significant residual effect on the succeeding toria crop which resulted the highest seed yield (1.07 ton ha^{-1}) which was 69.8% higher than the control and 44.6% higher over the residue of 100% RDF . The gross return, net return and return $rupee^{-1}$ invested for the whole system established superiority with the combined application of 75% RDFN + 25% N by vermicompost followed by 50% RDFN + 50% N by VC.

Keywords : Maize-toria cropping sequence, Integrated Nutrient Management, residual effect, System economy, Yield attributes.

Introduction

Large area of Odisha is predominantly under monocropping system and rice is grown even under dry upland conditions in *kharif*. Maize-toria is preferable cropping sequence by farmers in many parts of the country (Islam *et. al*., 2012). The maize-toria sequence is most prevalent in Odisha due to its higher potential yield and owing to the capacity of maize to tolerate drought better than paddy in *kharif* upland condition and toria can be well taken as sequence crop due to its high value, less duration, and capacity to grow under residual soil fertility and minimum soil moisture. As such, the oil yield from toria will help decrease the import of edible oil. Its oil is used for vegetable, condiments, fodder and medicinal purposes for remedy against stomach and skin disease etc. In this system both the crops are fertility exhaustive and deplete soil fertility extensively, necessitated the need for integrated approach in nutrient management in both the crop. Presently, fertilizer application is based on the nutrient requirement of individual crop and the carry over effect of manure and fertilizer applied to preceding crop are generally ignored. Most of the crops respond quickly to chemical fertilizers and give higher yield and maize is more responsive. But, continuous application of chemical fertilizers alone had been reported to deteriorate soil health. Kovacik *et al.*, (2014) reported that vermicompost application accelerates the ripening process of the crop upto 1-2 weeks which help in taking successive crop like toria. Productivity of crops is a function of genetic potential of crop varieties, soil productivity and environmental condition through its internal, physiological and biological processes. Of these, soil productivity assumes paramount importance. For maintenance of soil fertility and productivity, nourishing the soil by addition of organic manures along with chemical fertilizers in right amount and proper balance is necessary to get higher production on sustainable basis, (Inderjeet *et al*., 2014). It is important to identify the best type of available organic resources which can be used as fertilizers and their best suitable combination with appropriate proportion of inorganic fertilizers. Hence, present investigation was conducted to find out best combination of organic and inorganic fertilizers for maximum production in maize and its residual effect on toria in maize-toria cropping sequence with higher income level without affecting soil qualities.

Objectives

(a) To study the effect of integrated nutrient management on growth of hybrid maize and its residual effect on growth of toria in maize-toria sequence.

(b) To study the effect of integrated nutrient management on yield attributes and yield in hybrid maize and its residual effect on yield attributes of toria in maize-toria sequence.

(c) To study the effect of integrated nutrient management on system economics in maize-toria sequence.

Materials and Methods

A field experiment was conducted in randomized block design, consisting of eight treatments with three replications, at research farm of Regional Research & Technology Transfer Sub Station, Kirei, Sundergarh, OUAT of Odisha state (22^0 4' N and 84^0 2' E with average annual rainfall of 1422.45 mm), during *kharif* and *rabi* 2013 and 2014.

The soil of the experimental site was sandy loam with pH of 6.74, Electrical conductivity 0.86 dSm^{-1}, low in organic carbon (4.2 g kg^{-1}), low in available nitrogen (216 kg ha^{-1}) and medium in phosphorus (14 kg ha^{-1}) and medium in potassium (187 kg ha^{-1}). Maize hybrid Cv PMH-3 was sown on 10^{th} June and toria Cv. Anuradha on 20^{th} September and 12^{th} June and 22^{nd} September in 2013 and 2014, respectively in specified crop geometry and all farm operations were conducted as per recommendations of the crops. The eight treatments consists of T_1 (100% RDF), T_2 (75% RDFN + 25% N by vermicompost), T3 (75% RDFN + 25% RDFN by MOC), T4 (75% RDFN + 25% N by FYM), T_5 (50% RDFN + 50% N by VC), T_6 (50% RDFN + 50% RDFN by MOC), T_7 (50% RDFN + 50% N by FYM) and T_8 (Control) for maize-toria cropping sequence. The soil test based RDF used in treatment was 120-6-60 kg NPK ha^{-1}, out of which whole P and K were applied at the time of sowing and N was applied in 3 split doses as 50% at the time of sowing, 25% at 20 days after sowing (DAS), and remaining 25% at the time of tasseling (i.e at 60 DAS). After harvest of maize, the plots were not dismantled but prepared manually and no fertilizers were applied and toria was sown in *rabi* season. Regular biometric observations were recorded at specific time intervals by selecting randomly 5 plants in each treatment. Maize was harvested on 15^{th} September and toria on 5^{th} December and on 17^{th} September and 7^{th} December in 2013 and 2014 respectively. Growth and yield attributes and yield were recorded after harvesting of crops. Gross return, Net return and return $rupee^{-1}$ invested of each of the treatment were calculated consecutively for two years as well as pooled data taking into account of all the components of cost of cultivation and cost of produce involved in the treatment for the whole system. The data were analyzed statistically for comparing the treatment means.

Results and Discussion

Growth and yield attributes of maize

Growth attributes of maize *viz*., plant height, leaf area index and dry matter accumulation showed varied results. (Table 1). Lowest values were observed with control. Significantly higher plant height of 220.8 cm , the highest dry matter of 1745 g m^{-2} d^{-1} were recorded at harvest and significantly higher LAI of 5.15 at 60 days after sowing by treatment T_2 (75% RDFN + 25% N by vermicompost) followed by treatment T_1 (100% RDF). The highest dry matter accumulation at harvest in T_2 was at par with T_7 (50% RDFN + 50% N by FYM).

The yield attributing characters (Table 2) like number of grains cob^{-1}(466.49) was highest with T_2 which was at par with T_5 (50%RDFN + 50% N by VC) and significantly the higher grain weight cob^{-1}(102.67 g) was recorded with T_2. The highest number of grains cob^{-1} and grain weight cob^{-1} were higher over 100% RDF by 15.9 and 16.8%, respectively. This improvement in growth and yield components of maize with application of integration of organic and inorganics might be because of higher availability of macro and micronutrients with the combined application of inorganic and organic sources of nutrients. Chandrasekhar *et al*., (2000) and Sujatha *et al*., (2008) observed similar beneficial effect of organic manures on different growth and yield attributes.

Yield of maize

The data presented in Table 2 showed that significantly higher grain yield (6.79 t ha^{-1}) and highest stover yield (10.95 t ha^{-1}) of maize were obtained with 75% RDFN + 25% N by vermicompost. Increase in maize grain and stover yields owing to vermicompost might be attributed to steady release of nutrients to soil for longer duration after decomposition resulting in better plant growth and yield attributing characters. This finding was in conformity with the observation by Munda and Islam (2007).

Growth and yield attributes of toria

The residue of 50% RDFN + 50% N through VC applied to maize influenced the growth attributes like plant height, leaf area index and dry matter and yield attributes like number of silquae $plant^{-1}$ and number of seeds $siliqua^{-1}$ in succeeding toria. The highest plant height of 118.8 cm, significantly higher dry matter of 322.58 g m^{-2} d^{-1} were recorded at harvest by T_5 (50% RDFN + 50% N by vermicompost) followed by T_2 (75% RDFN + 25% N by vermicompost). The highest leaf area index of 3.39 was recorded at 45 days after sowing (DAS), which was at par with T_2 (100% RDF). Biman *et al.*, (2013), reported that the highest leaf area was due to accumulation of soluble nitrogen, sugar, starch, proline and increased internal CO_2 concentration and net photosynthesis from the combined application of organic and inorganic sources of nutrient (Table 1).

The yield attributing characters (Table 2) like number of silquae plant^{-1} (113) and number of seeds siliqua^{-1} (10.10) were the highest with T_5 (50% RDFN through inorganic fertilizer + 50% N through vermicompost) which was at par with T_2 during both the years of experimentation, (Table-2). On pooled data basis, the highest values recorded in T_5 were higher over residue of 100% RDF by 2.27 and 3.8%, respectively. Kumar *et al*., (2005) observed similar beneficial effect of organic manures on different growth and yield attributes

Table 1 Effect of integrated nutrient management on growth of hybrid maize and its residual effect on growth of toria in maize-toria sequence (pooled data)

	Maize (growth attributes)			Toria (growth attributes)		
Treatments	Plant height (cm)	Leaf area index (60 DAS)	Dry matter accumulation at harvest (g m^{-2})	Plant height (cm)	Leaf area index (45 DAS)	Dry matter accumulation at harvest (g m^{-2})
T_1	204.6	4.55	1608.4	84.6	2.40	267.31
T_2	220.8	5.15	1745.0	107.9	3.12	300.14
T_3	181.4	4.21	1595.5	84.3	1.97	258.87
T_4	200.8	4.47	1593.1	92.8	2.70	276.60
T_5	185.4	4.27	1582.0	108.7	3.39	322.58
T_6	178.6	4.07	1471.1	84.4	2.65	265.53
T_7	179.3	4.05	1617.4	94.1	2.78	276.09
T_8	159.6	3.05	850.4	68.4	2.30	259.21
SEm (+)	4.73	0.15	42.46	2.3	0.10	5.34
CD (0.05)	14.46	0.47	128.79	7.0	0.31	16.21

Table 2 Effect of integrated nutrient management on yield attributes and yield in hybrid maize and its residual effect on yield attributes of toria in maize-toria sequence (pooled data)

	Maize (Yield attributes & yield)			Toria (Yield attributes & yield)		
Treatments	Number of grains cob^{-1}	Weight of grains cob^{-1} (g)	Grain yield (t ha^{-1})	Number of siliquae plant^{-1}	Number of seeds siliqua^{-1}	Seed yield (t ha^{-1})
T_1	402.15	87.89	5.83	99.35	9.46	0.74
T_2	466.49	102.67	6.79	110.49	9.73	0.97
T_3	406.01	82.91	5.48	97.09	9.18	0.75
T_4	408.65	88.80	5.92	97.11	9.35	0.73
T_5	441.84	89.74	5.99	113.00	10.10	1.07
T_6	368.74	76.50	5.10	100.65	9.33	0.81
T_7	404.84	86.36	5.75	99.55	9.48	0.74
T_8	217.81	45.06	2.97	95.86	9.25	0.63
SEm (+)	13.95	2.37	0.17	2.86	0.21	0.03
CD (0.05)	42.33	7.20	0.52	8.67	0.63	0.09

Table 3 Effect of integrated nutrient management on system economics in maize-toria sequence (pooled data)

Treatments	Maize equivalent yield (t ha^{-1})	Gross return (□ ha^{-1})	Net return (□ ha^{-1})	Return rupee^{-1} invested (□)
T_1	7.53	97872	52633	2.19
T_2	9.10	118273	66784	2.31
T_3	7.20	93586	42977	1.87
T_4	7.23	94040	48801	2.12
T_5	8.38	108965	47965	1.74
T_6	6.99	90865	31865	1.55

T_7	7.45	96908	49408	2.19
T_8	4.43	57595	22645	1.62
SEm (+)	0.16	2052	2052	0.04
CD (0.05)	0.48	6224	6224	0.13

Note: Market price of maize □ 1300 q^{-1} and of Toria is □ 4000 q^{-1}

RDF-Recommended dose of fertilizer, RDFN-Recommended dose of fertilizer nitrogen, VC-Vermicompost, MOC- Mustard oil cake, FYM-Farm yard manure.

T_1 : 100% RDF, T_2 : 75% RDFN + 25% N by VC, T_3 : 75% RDFN + 25% N by MOC,

T_4 : 75% RDFN + 25% N by FYM, T_5: 50% RDFN + 50% N by VC, T_6: 50% RDFN + 50% N by MOC , T_7: 50% RDFN + 50% N by FYM, T_8: Control (No manure and no nitrogen fertilizer).

Yield of toria

Table 2 showed that residue of 50% RDFN + 50% N by vermicompost resulted significantly higher seed yield (1.07 t ha^{-1}) t ha^{-1}) followed by the residue of 75% RDFN + 25% N by vermicompost (0.97 t ha^{-1}) which was presented in Table 2. However, the highest stover yield of 1.92 was recorded with T_2 which was at par with T_5 (1.86 t ha^{-1}). Chanda (2007) reported similar observation. Beneficial effect of inorganic fertilizers applied to preceding crop on the productivity of succeeding crop was also observed by Das *et al.* (2004). This might be due to the presence of highly persistent material, i.e. cellulose in vermicompost which requires long time for complete decomposition. Thus nutrient release from vermicompost for long time period notably benefitted the succeeding toria crop.

System Economics

The economics of the system (Table 3) was positively influenced by different inorganic and organic treatments. The significantly higher gross return of □ 1,18,273 ha^{-1}, highest net return of □ 66,784 ha^{-1} with highest return rupee^{-1} invested of 2.31 were recorded with treatment T_2 (75% RDFN + 25% N by vermicompost) in maize-toria cropping sequence. The highest value of gross return, net return and the return rupee^{-1} invested obtained with treatment T_2 (75% RDFN + 25% N by VC) was followed by T_1 (100% RDF). This might be due to improvement in soil health owing to continuous supply of nutrients. Our results confirmed the findings of Tomar and Tiwari (1990). Dhiman, M. (2014) opined that the highest net return as well as benefit : cost ratio was registered with application of various organic sources of nutrient in combinations instead of their application alone

Summary and Conclusion

Thus from the foregoing discussion, it could be concluded that 75% RDFN through inorganic fertilizer and 25% N through vermicompost applied to maize and the residue of 50% RDFN through inorganic fertilizer and 50% N through VC to toria not only increased the yield and yield attributes but also the higher system economic return in maize-toria cropping sequence which could help farmers in doubling their farm income.

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Effect of Plant Growth Regulators on Yield Parameters of Okra (*Abelmoschus Esculentus* l. Moench)

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Abstract: The field experiment was conducted at Chilli and Vegetable Research Unit, Dr. PDKV, Akola during *kharif* season of 2017 with three replications and thirteen treatments in randomized block design. The experiment consisted of promising okra genotype (AKOV-107) and four different plant growth regulators, study was carried out to evaluate the foliar sprays of plant growth regulators viz., GA_3, NAA, salicylic acid and chitosan with three different concentrations of each and one control (without spray) replicated three time. Observations recorded on ten different parameters like days to first anthesis, days to 50% flowering, length of reproductive phase, days to first harvest, fruit picking period, number of fruits per plant, number of seeds per fruit, single fruit weight, fruit yield per hectare and harvest index. Foliar application of 150 ppm GA_3 and 200 ppm NAA have beneficial role on plant growth parameters along with fruit yield of okra.

Keywords: Okra, Growth, Yield, Plant Growth Regulators, GA_3, NAA, Salicylic Acid, Chitoson.

Introduction

Okra (*Abelmoschus esculentus* L. Moench) popularly known as 'Bhendi' (ladies finger) is an important warm season vegetable, widely cultivated for its tender, green fruits. Okra is a tall annual dicotyledonous plant related to cotton and thought to be of African origin. Okra pods are harvested when they reach the maximum size but still tender around 5-10 days after opening of flower depending on the cultivar grown. Average nutritive value (ANV) of okra is 3.21 which is higher than tomato, eggplant and most of the cucurbits, except bitter gourd (Grubben, 1977). Okra dry seed contains 18-20 per cent oil and 20-23 per cent crude protein.

The discovery of plant growth regulators is an outstanding achievement, which was contributed a good deal to the progress of horticulture science. Plant growth regulators are considered new generation of agro-chemicals after fertilizers, pesticides and herbicides. Plant growth regulators have potential to increase productivity of vegetables. It is therefore very important to choose proper growth regulators along with their proper concentration for getting higher production of okra. Keeping all above factors in view, the proposed study was planned with the objective to find out suitable growth regulator along with their concentration for obtaining more fruit yield of okra.

Material and Methods

An investigation entitled "Effect of plant growth regulators on growth and yield of okra (*Abelmoschus esculentus* L. Moench)" was conducted at the experimental field of Chilli and Vegetable Research Unit, Dr. PDKV, Akola during *kharif* season of 2017. The experiment was laid in a randomized block design (RBD) with three replications. Okra variety AKOV-107 was sown on 12-07-2017 at 60x60 cm spacing. All the cultural practices were followed to raise good crop. Foliar application of different plant growth regulators T_1 (NAA-100 ppm), T_2 (NAA-150 ppm), T_3 (NAA-200 ppm), T_4 (GA_3-100 ppm) , T_5 (GA_3-150 ppm), T_6 (GA_3-200 ppm), T_7 (Chitosan-100 ppm), T_8 (Chitosan-125 ppm), T_9 (Chitosan-150 ppm), T_{10} (Salicylic acid-500 ppm), T_{11} (Salicylic acid-1000 ppm), T_{12} (Salicylic acid-1500 ppm), T_{13} (control -without spray) are done at 15, 30 and 45 days after sowing. Observations were recorded on five randomly selected plants from each treatment per replication. The data recorded on ten different growth parameters like days to first anthesis, days to 50% flowering, length of reproductive phase, days to first harvest, fruit picking period, number of fruits per plant, number of seeds per fruit, single fruit weight, fruit yield per hectare and harvest index. The data were analysed statistically as per standard method of Panse and Sukhatme (1985)

Result and Discussion

The response with growth regulators depend upon the amount of particular compound absorbed by the seed or plant and ability of the stimulus of the chemical applied. It is however, believed that the mechanism of the action of a growth regulator in plant through same fundamental process involving the activities of the enzyme concerned in the process.

Days to First Anthesis

The data presented in table1 showed that minimum days of 37.33 days require to first anthesis in treatment T_5 (GA_3 at 150 ppm) and T5 (NAA at 200 ppm) while, maximum days to first anthesis 48.33 days was recorded in treatment T_{13} (Control).

The application of plant growth regulators through seed soaking or foliar spray has been observed to produce early flowering due to suitable carbohydrates content. Thus accumulation of the accelerated photosynthates in the plant more than that required for the growth were translocated towards the development of productive part thus cause early flower initiation. Similar results also reported by Deepak *et al.* (2007), Patil *et al.* (2008) and Dhage *et al.* (2011) in okra.

Days to 50% Flowering

The data presented in table1 showed that significantly minimum days were required to 50% flowering in treatment T_5 (GA_3 at 150 ppm) 40.67 days followed by T_3 (NAA at 200 ppm) 41.00 days. The maximum 50.00 days required for 50% flowering was recorded in treatment T_{13} (Control).

Early flowering in T_5 treatment (GA_3 at 150 ppm) might be due to its involvement in transition of vegetative apices to floral apices remained physiologically more active to build up sufficient food reserve for developing flower. Similar results were reported by Katung *et al.* (2007), Kokare *et al.* (2006) and Chowdhury *et al.* (2014) in okra.

Days to Harvest

The data presented in table1 showed that significantly minimum days to first harvest was recorded in treatment T_5 (42.33 days) followed by treatment T_3 (43.00 days) while, maximum days require to first harvesting 54.33 days was recorded in treatment T_{13} (Control). Similar results were also reported by Syed *et al.* (1997) and Faten *et al.* (2004) in okra.

Single Fruit Weight (gm)

The data presented in table 1 showed that significantly the maximum single fruit weight was recorded in the treatment T_5 (GA_3 at 150 ppm) 17.95 gm followed by T_3 (NAA at 200 ppm) 17.88 gm whereas, the minimum single fruit weight of 13.35 gm was recorded in treatment T_{13} (Control). Similar results was reported by Shingh *et al.* A (2012) and Shingh *et al.* B (2012).

Number of Fruits Per Plant

The data presented in table 1 revealed that significantly the maximum number of fruits per plant was produced in the treatment T_5 (GA_3 at 150ppm) 19.97 followed by T_3 (NAA at 200 ppm) 19.50 with average mean value of 17.28. However, the minimum number of fruits per plant 13.33 was recorded with the treatment T_{13} (Control).

The physiological action of GA_3 and NAA might have been responsible for increase in the number of fruits. Further, accumulation of greater dry matter content due to better photosynthetic, other metabolic activities and efficient nutrient uptake from soil in okra due to hormonal activity of both the regulators directly reflects in more number of fruit production. Similar results were also reported by Shingh *et al.* A (2012), Ayyub *et al.* (2013) and Chowdhury *et al.* (2014) in okra.

Fruit Picking Period (Days)

The data presented in table 1 showed that significantly maximum fruit picking period of okra plant in terms of days was recorded in treatment T_5 (GA_3 at 150 ppm) 57.89 days followed by treatment T_3 (NAA at 200 ppm) 56.33 days while minimum length of fruit picking period of okra plant 39.78 days was recorded in treatment T_{13} (Control) with average mean of 53.00 days. Similar results were also reported by Patil *et al.* (2014) in okra.

Length of Reproductive Phase (Days)

The data presented in table1 showed that significantly maximum length of reproductive phase of okra plant in terms of days was recorded in treatment T_5 (GA_3 at 150 ppm) 62.53 days followed by treatment T_3 (NAA at 200 ppm) 61.53 days while minimum length of reproductive phase of okra plant 46.33 days was recorded in treatment T_{13} (Control) with average mean of 55.94 days. Their findings are supported with finding of Patil *et al.* (2014) in okra.

Number of Seeds Per Fruit

The data presented in table 1 showed that significantly the maximum number of seeds per okra fruit was produced in the treatment T_5 (GA_3 at 150ppm) 60.80 followed by treatment T_3 (NAA at 200 ppm) 59.00 however, the minimum number of seeds per fruits 50.67 were recorded in the treatment T_{13} (Control). The higher percentage of bolder seeds coupled with the heavier seed weight due to increased translocation and assimilation of photosynthates from source to seeds in okra. Similar results were also reported by Shingh *et al.* A (2012), Ayyub *et al.* (2013) and Mohammadi *et al.* (2014).

Fruit Yield (q/ha)

The data presented in table 1 revealed that significantly the maximum okra fruit yield was recorded in the treatment T_5 (GA_3 at 150 ppm) 141.42 q/ha followed by T_3 (NAA at 200 ppm) 139.91 q/ha whereas, the minimum okra fruit yield of 94.61 q/ha was recorded in treatment T_{13} (Control) with general mean values of 125.82 q/ha.GA_3 increased photosynthetic activities within the plant which might be resulted in more production of carbohydrates and related products responsible for increase in growth of fruit size, higher fruit set, number of fruits and ultimately results in higher yield. Greater accumulation of carbohydrates in the plants is necessary in order to facilitate the development of fruit and increase in yield. Similar results were also reported by Bala Hussani (2004), Singh *et al.* A (2012), Singh *et al.* B (2012) and Chowdhury *et al.* (2014) in okra.

Table 1: Effect of plant growth regulators on yield and yield contributing characters of okra

Treatments	Days to first anthesis	Days to 50% flowering	days to first harvest	Single fruit weight (gm)	Number of fruit/ plant	Fruit picking period (days)	Length of reproductive phase (days)	Number of seed/ fruit	Fruit Yield (q/ha)	Harvest index
T1: NAA-100 ppm	41.33	43.33	44.67	15.49	16.17	51.67	53.07	54.33	119.34	71.77
T2: NAA-150 ppm	38.00	41.67	43.00	16.95	17.87	54.67	57.00	56.50	131.34	77.61
T3: NAA-200 ppm	37.33	41.00	43.00	17.88	19.50	56.33	61.53	59.00	139.91	78.87
T4: GA3-100 ppm	38.00	41.33	43.33	17.28	18.40	55.00	59.20	57.83	134.34	78.27
T5: GA3-150 ppm	37.33	40.67	42.33	17.95	19.97	57.89	62.53	60.80	141.42	79.71
T6: GA3-200 ppm	39.33	43.00	44.33	16.43	16.53	52.33	53.87	54.57	121.40	72.77
T7: Chitosan-100 ppm	38.00	41.33	43.33	17.81	19.17	56.33	60.27	58.73	137.51	78.34
T8: Chitosan-125 ppm	38.33	42.00	43.33	16.54	17.50	54.67	56.60	55.67	126.88	77.24
T9: Chitosan-150 ppm	40.67	43.67	45.00	15.43	15.33	51.67	52.00	52.87	117.28	70.22
T10: Salicylic acid-500 ppm	39.67	42.33	43.67	16.49	17.10	53.00	54.47	55.33	124.48	74.93
T11: Salicylic acid-1000 ppm	38.00	41.33	43.33	17.77	18.80	56.00	59.97	58.30	135.11	78.34
T12: Salicylic acid-1500 ppm	40.67	44.33	46.00	14.33	14.97	50.33	50.33	50.77	112.13	69.66
T13: Control	48.33	50.00	54.33	13.35	13.33	39.78	46.33	50.67	94.61	69.21
mean	39.62	42.77	44.59	16.44	17.28	53.00	55.94	55.80	125.82	75.15
SE m ±	1.98	1.35	2.07	0.96	1.02	3.09	3.23	2.11	8.37	2.63
CD @ 5%	5.79	3.94	6.04	2.80	2.99	9.02	9.42	6.16	24.43	7.69

Harvest Index (%)

The data presented in table 1 Showed that significantly the maximum harvest index obtained in the treatment T_5 (GA_3 at 50 ppm) 79.71% followed by T_3 (NAA 200 ppm) 78.87 % and T_7 (chitosan 100 ppm) 78.34% however, the minimum 69.21% harvest index was recorded in treatment T_{13} (Control). Similar results were reported by Mondal *et al.* (2013) in mungbean.

Conclusion

The yield attributing characters viz., fruit weight, number of fruit per plant and fruit yield q/ha found significantly maximum in T_5 (GA_3 at 150 ppm). Similarly minimum days to 50% flowering and days to first harvest recorded in treatment of T_5 (GA_3 at

150 ppm). Among all treatments , the treatment T_5 (GA_3 at 150 ppm) showed promising result in all the parameters followed by T_3 (NAA 200 ppm), T_7 (chitosan 1000 ppm) and T_{11} (salicylic acid 100 ppm).

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Influence of Different Sowing Windows on Seed Quality of Soybean

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Abstract: A field experiment entitled "Influence of Different Sowing Windows on Yield Contributing Characters of Soybean'' was conducted during Kharif 2019 on field of Department of Agril. Botany Dr. PDKV Akola. The trial was laid out in RBD design with three replication and nine dates of sowing after the onset of monsoon at one week interval with Soybean variety JS-335 with an objective to evaluate the effect of sowing windows on seed quality parameters. The findings of the experiment revealed that the seed quality parameters i.e., germination percentage, seed index, seed vigour indices I & II and electrical conductivity of the seeds obtained from different sowing dates shows significant differences. The good germination percentage was observed in seeds obtained from first sowing T1 (91.5%) which gradually decreases with delay in sowings. The Higher Seed Index of 11.64 g was recorded for July 1st week sowing (T2.) The highest Seedling Vigour index-I (3309.45) and Seedling Vigour Index-II 81.71) was recorded with June 4th week sowing (T1). The lower electrical conductivity (0.164 dSm^{-1}) was recorded for seeds obtained from early sowing of June 4th (T1), with delay in sowing the seeds so obtained shows increase in Electrical Conductivity. Sowing in July 1st week (T2) recorded significantly higher seed yield per plant (13.45 g).

Keywords: Soybean, sowing date, Yield, seed quality, vigour index, EC, seed index.

Introduction

Soybean (Glycine max L.) popularly known as "Golden bean" Soja bean, Soya bean, Chinese pea and Manchurian bean which belongs to family Leguminaceae, sub family fabaceae and genus glycine is one of the most important oil seed crops known for its excellent protein (42-45%), oil (22%) and starch content (21%). The crop is one of the likely solutions for overcoming the world's protein hunger and a good source of vitamin B complex, particularly thiamine and riboflavin. Soybean protein is rich in valuable amino acids like lysine (5%) in which, most of the cereals are deficient. Soybean can substitute for meat and to some extent to milk. Soybean is native of Eastern Asia. The crop has been recently introduced in India and is considered both pulse as well as oilseed crop. India is the fifth largest producer of soybean in the world after USA, Brazil, China and Argentina. The United States of America is the largest producer, contributing 32% of the world's soybean production. In India, it is grown on an area of 12 M ha with a production of 9.30 mmt and productivity of 0.78 t ha^{-1} in 2019 (USDA). In India, major soybean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh and Andhra Pradesh. In Maharashtra, total area under cultivation is 3.73 M ha in Kharif season 2019 with production of 3.94 mmt and productivity of 1.05 t ha^{-1} (SOPA). The many factors limiting soybean production are improper sowing time, climatic variability, low germination percentage, poor quality seed, irrigation shortage etc. Among the agronomic practices sowing date has remarkable influence on soybean yield. However, the effect of sowing date on soybean grain depends on genetic and environmental conditions, sowing date is an important factor affecting soybean growth, development, seed yield and quality. Sowing date is the most important and least expensive cultural consideration that impacts soybean seed quality. The optimum time of sowing, enables favourable environmental conditions for growth and seed quality. Generally, the sowing date varies depending on the climatic condition of the region and the varieties to be grown.

Material and Methods

The present investigation entitled "Influence of Different Sowing Windows on Seed Quality of Soybean" was conducted during Kharif-2019 at field of Department of Agril. Botany, Dr. PDKV, Akola. The study included Soybean Var. JS-335. The Nine sowing dates on the onset of monsoon having one week interval with three replications of Soybean is tested in Randomized Block Design. The recommended cultural practices were followed to raise a good and healthy crop. The sowing is done by dibbling method with spacing of 45x10 cm spacing. This study included both field as well as laboratory evaluation to investigate the effect of different sowing dates on Soybean. All the observations were recorded on randomly selected plants in each replication and the mean values were considered for statistical analysis. The laboratory test was conducted at Seed Technology Research Unit Dr. PDKV Akola.

Result and Discussion

DAYS TO 50 % FLOWERING: Date of sowing had significant influence on the days to 50% flowering (Table1). This trait recorded a general mean value of 35.37 days ranged from 30.66 to 40.66 days. Days to 50% flowering was found to be early in August 4th week (T9) sowing (30.66 days) followed by August 3rd week (T8) sowing (32.33 days) and were significantly different from each other. Days to 50% flowering was late in June 4th week (T1) sowing (40.66 days). The days to 50 % flowering was early in August 4th (T9) week sowing might be due to exposure of the crop to warm temperature and short photoperiod which reduced the vegetative phase and triggered the reproductive phase very quickly. Deshmukh *et al.* (2019), Kumar *et al.* (2018) revealed that the characters 50% flowering and days to maturity of soybean were significantly affected by sowing dates in Kharif. Chen and Wiatrak (2010) finds duration of flowering decreased with later planting date.

DAYS TO MATURITY: Sowing dates differed significantly for days to maturity (Table1). This trait ranged from 80.33 to 95.33 days with mean value of 86.44days. Late maturity (95.33 days) was observed in June 4th week (T1) followed by July 1st week (T2) sowings (93.33 days) which were statistically at par with each other but significantly different from all other treatments. The early maturity of plants was observed in August 4th week (T9) and August 2nd week (T7) sowing (80.33 & 80.66 days respectively). Significant reduction in days to maturity was observed at each successive sowing date. Early maturity in August 4th week (T9) sown crop might be due to higher temperature and huge difference in maximum and minimum temperature during crop growth period, which accelerated development towards reproductive stage and hence less time was available for the plant for vegetative growth and leading to early maturity.

Table 1. Effect of Different Sowing Windows on seed quality of Soybean Crop.

Treatments	Days to 50% Flowering	Days to Maturity	Yield plant-1 (gms)	seed Index (gms)	Germination	VI-I	VI-II	EC
T1	40.66	95.33	10.97	10.33	91.5	3309.45	81.71	0.164
T2	38.33	93.33	13.45	11.64	90.5	3192.31	74.28	0.183
T3	36.66	91.66	10.7	10.27	88.83	2965.57	63.02	0.194
T4	35.66	88.66	8.98	9.05	88.66	2846.64	58.90	0.215
T5	35.33	85.66	7.71	9.40	88.16	2882.56	56.32	0.222
T6	34.33	81.33	5.64	8.33	86.50	2682.45	54.70	0.252
T7	34.33	80.66	3.18	7.60	85.16	2519.16	49.28	0.258
T8	32.33	81	2.60	7.15	85.83	2498.70	48.33	0.283
T9	30.66	80.33	2.75	7.08	84.83	2372.27	47.29	0.307
Mean	35.37	86.44	7.33	8.98	87.77	2807.68	59.31	0.231
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.46	0.51	0.22	0.25	0.56	22.75	9.70	0.01
CD at 5%	1.39	1.54	0.678	0.77	1.68	68.48	2.92	0.03

These results are in accordance with the findings of Islami and Sugito (2012) who explained that the number of days to maturity of soybean declined with each successive sowing date due to high temperatures during vegetative development which might have shortened intervals between vegetative and reproductive growth stages. Bateman *et al.*(2020) and Morsy *et al.* (2016) also supported the findings.

SEED YIELD PLANT^{-1}(g): Date of sowing significantly influenced the seed yield per plant. This trait recorded general mean value of 7.33 g with a range of 2.75 to 13.45 g (Table 1). Sowing in July 1st week (T2) recorded significantly higher seed yield per plant (13.45 g) followed by June 4th week (T1) (10.97 g) and July 2nd week sowing (T3) (10.7 g). Minimum seed yield plant^{-1}(2.75 g) was obtained from August 3rd week (T8) sowing. This might be due to production of lower number of pods plant^{-1} with smaller seed size. High temperatures (>30°C) at reproductive stage might have affected pollination, fertilization and consequently poor pod set resulting in lower number of pods per plant (Chen and Wiatrak, 2010). The present findings are also supported by Elmore (1990). Earlier sowing probably had more period for vegetative and reproductive growth compared to later dates of sowing which had smaller vegetative and reproductive period causing reduction in growth and development and ultimately produced smaller number of pods plant^{-1}. Also these findings were supported by Madhavi *et al.* (2000) and Kumar *et al.* (2018) who reported that seed yield plant^{-1}decreased with delay in sowing date due to lack of sufficient vegetative growth, lower number of pods plant^{-1}and reduced seed weight and ultimately resulted in lower seed yield of plant. Also Pierozan *et al.* (2017) evaluated the grain yield plant^{-1} decreased with delay of sowing.

SEED INDEX (g): Seed index was significantly affected by sowing dates and this trait ranged from 11.64 to 7.08 g (Table 1). Higher 100 seed weight 11.64 g was recorded for July 1st week (T2) sowing followed by June 4th week (T1), July 2nd week (T3), July 4th week (T5), July 3rd week (T4) and so on. Lowest seed index(7.08 g) was recorded for seeds from August 4th week (T9) sowing. The seed index significantly declined when sowing was delayed from June to August. The highest 100 seed weight recorded in July sowings might be due to optimum climate and sufficient time for growth and pod filling, which enabled the plants to produce bold seeds while, late sowings decreased the effective rate of pod filling and shortened the effective duration of pod filling compared with earlier sowings. Heat stress during seed development stage caused the poor seed development and reduced the seed size in soybean. Higher seed index recorded with early sowing might be due to favorable weather conditions coupled with more number of growing days during reproductive stage which might have helped in translocation of more assimilates into seeds and subsequently developed to bold seeds with early sowing. Results obtained are in consonance with Billore *et al.* (2000) and Halvankar *et al.* (2001).

GERMINATION PERCENTAGE: Significant variations realized for standard germination percentage among different sowing dates of soybean. Germination ranged from 84.83 to 91.50% with 87.77 % as general mean. The highest germination percentage was recorded in seeds obtained from June 4th week (T1) sowing (91.5%) followed by July 1st week (T2) sowing (90.5%). The lowest germination observed in seeds obtained from August 4th week (T9) sowing (84%).The relatively higher germination of the seeds obtained from early sowing could be due to the fact that, the early planted crop availed sufficient time for reproductive development, seed filling and maturity than the late sown crop. The decreased germination percentage of the delayed sowing dates is due to reduced span of reproductive phase, undeveloped seeds, seed weight and early maturity. Longer day length during reproductive stage coupled with favorable weather conditions that prevailed during grain filling and maturity stages of the crop growth are helpful in improving the seed quality of soybean as observed in early sown crop. The results obtained are in conformity with Uem and Unioeste (2003) who reported that seeds from the optimum planting dates had higher percentage of germination than the early or delayed planting crop. In soybean, a late sowing date decreased the germination percentage of seed. Venkatesh *et al.* (2019) also founds similar result. Also Deshmukh *et al.* (2018) found that the quality of seeds from late sowings deteriorates with late sowings in soybean.

VIGOUR INDEX I: Vigour index-I differed significantly among the sowing dates. This trait ranged from 3309.45 to 2372.27 with a general mean value of 2807.68. The highest seedling vigour index-I (3309.45) was recorded with June 4th week sowing (T1) followed by July 1st week sowing (T2) (3192.31) and were statistically significant from all treatments. The lowest seedling vigour index-I recorded with August 4th week (T9) sowing (2372.27). Higher seedling vigour index recorded in June 4th week sowing could be attributed to high root and shoot length besides good seed germination. High seedling vigour index could be attributed to increased seedling dry weight besides good seed germination. The variation in seed germination and vigour comes from the environmental conditions that the crop experiences during the seed development and maturation. These findings are in line with reports of Rahman *et al.* (2013) who reported that seeds from optimum time of sowing had high seedling vigour index because of high seed quality.

VIGOUR INDEX II: Vigour Index-II shows significant difference among the sowing dates ranges from 81.71 to 47.29 with a mean value of 59.31. The highest seedling vigour index-II (81.71) was recorded with June 4th week (T1) sowing followed by July 1st week (T2) sowing (74.28). The lowest seedling vigour index-II (47.29) was recorded with August 4th week (T9) sowing. High seedling vigour index recorded could be attributed to increased seedling dry weight besides good seed germination.

ELECTRICAL CONDUCTIVITY (dSm^{-1}): There was a significant difference for electrical conductivity between different sowing dates. This trait ranged from 0.164 to 0.307 dSm^{-1} with a general mean value of 0.23 dSm^{-1}. Higher electrical conductivity was recorded for seeds from August 4th (T9) week sowing (0.30 dSm^{-1}) followed by August 3rd week (T8) sowing (0.28 dSm^{-1}) while, lower electrical conductivity (0.164 dSm^{-1}) was recorded for seeds from June 4th (T1) sowing followed by July 1st week (T2) sowing (0.18 dSm^{-1}) and were statistically on par with each other. This might be due to high initial seed quality. Low value for electrical conductivity is an indicator of high seed viability since the EC value is inversely correlated with standard germination and other seed quality traits. The minimum EC was recorded with early sowing as they have favorable conditions for crop growth resulting in higher yields. Delayed sowing upto late August, where actually the crop experienced low temperature with high humidity and shorter day length forcing the crop to mature earlier which cumulatively might have resulted in more EC, though the yield was low. With regard to varieties, genetic makeup of variety, seed size, and relative humidity of the storage environment, mechanical damage and thickness of the seed coat, moisture content of seed usually influence the seed vigour. Vieira *et al.* (2004) stated that though there was direct relationship between electrical conductivity and field emergence, yet this relationship could be distributed under marginal conditions.

Conclusion

From the present investigation it can be concluded that Soybean crop sown a week after onset of monsoon for getting higher seed yield. A week after the onset of monsoon found to be optimum time for proper growth and development of the crop.

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Evaulation of Seed Priming on Growth and Yield of Chickpea (*Cicer arientinum* l.)

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Abstract: The present experiment entitled "Evaluation of seed priming on growth and yield of chickpea (*CICER ARIENTINUM* L.)" was conducted during Rabbi 2019 at experimental field of Pulses Research unit, Dr. PDKV, Akola to assess the suitable priming treatment for chickpea crop (variety: JAKI-9218). The experiment was laid out in randomize block design in three replication. The morpho-physiological traits viz. germination %, plant height, number branches, dry matter content, number of day required to 50% flowering were taken.. The morpho physiological i.e. plant height, number of branches, dry matter content, germination % showed significant increase in chickpea crop when seed priming was carried out with potassium nitrate for 4 hours. The number of days required to 50% flowering were recorded least in seed priming GA3 for 4 hours. Protein content also recorded significantly higher in seed priming with potassium nitrate for 4 hours. Yield and yield attributes were also significantly increased in seed priming with potassium nitrate for 4 hours. It is concluded that seed priming were with potassium nitrate for 4 hours recorded higher morpho-physiological characters over priming treatment and control.

***Keywords**: seed priming, Germination, Growth parameters. GA3, Potassium nitrate.*

Introduction

There are about 60 domesticated grain legume species in the word (Hedley, 2001). The chickpea is fifth most important legume in the world, on the basis of total production after soybean, groundnut, beans and peas (Muzquiz and wood, 2007). In India it is largest growing pulse crop. Botanical name of chickpea is *Cicer arietinum* L.. The genus cicer belongs to the family Leguminosae, sub family fabaceae of the tribe Vicieae. The somatic chromosome number of chickpea is 2n=16. The genus cicero contains about 40 species out of which 31 are perennial and 9 are annual (Ladizinsky and alder, 1976). Chickpea probably originated from south east Turkey. Four centers of diversity were identified in the Mediterranean, central Asia, the East and India, as well as a secondary centers of origin in Ethiopia (Vavilov,1951).

Seed priming is a process of controlled hydration of seeds to a level that permits pre-germination metabolic activity to proceed, but prevents actual emergence of the radicle. Benefits of seed priming includes, faster speed of emergence, enable seed to germinate and emerge even under adverse agro-climatic conditions, improve uniformity to optimize harvesting efficiency. increases shelf life of seeds, improves the resistance towards water and temperature stress, increase vigour for fast and strong plant development and increases yield potential.

Seed priming technique has been practiced in many countries including Pakistan, China and Australia and more than thousand trials has been conducted to evaluate the performance of priming in variety of crops. Fifty three farmers tested maize seed priming in kharif season in 1996 in tribal areas of Rajasthan, Gujarat and Madhya Pradesh; India (Harris et al. 1999). Almost all farmers thought that primed crops grew more vigorously, flowered and matured earlier and produced bigger cobs and higher yield. Independent measurements on a subset of 35 trials showed a mean increase in cob weight of 6% (Harris et al. 2001).

Seed priming have various techniques for improving the performance of the growth, emergence and yield of the crop. There are some techniques which are used i.e. hydro-priming, halo-priming, osmo-priming and hormonal priming.

Materials and Methods

The experiment was conducted in randomized block design. Treatments were as follows:

T1: Control	T2: Hydro priming for 4 hours
T3: Priming with 0.5% urea for 4 hours	T4: Priming with 1% urea for 4 hours
T5: Priming with 0.5% Ammonium sulphate for 4 hours	T6: Priming with 1% Ammonium sulphate for 4 hours
T7: Priming with 0.5% KNO3 for 4 hours	T8: Priming with 1% KNO3 for 4 hours
T9: Priming with 50 ppm GA3 for 4 hours	T10: Priming with 100 ppm GA3 for 4 hours
T11: Priming with 50 ppm chlormequat chloride for 4 hours	T12: Priming with 100 ppm chlormequat chloride for 4 hours

Field emergence and germination percentage

Emergence count was under taken on 8th day after sowing and was counted and noted for each plot and replications.

Growth Parameters

Plant height (cm)

Observations on plant height were recorded (cm) at 30, 60, and 90DAS. The height of the three observational plants from each treatment and replication was recorded with scale from the base of a plant to top most developing node.

Number of branches

The number of branches counted at 30, 60, 90 DAS and at harvest.

Dry matter production studies

For dry matter study, single plant from each treatment and replication was uprooted periodically at flowering, pod formation and at harvest. The plant samples were washed with tap water carefully in order to remove soil and dust particles adhered to it. The samples were allowed to dry at room temperature separately for 48 hrs. After drying the sample on open air basis, the plant sample was finally dried in hot air oven at 70^{0}C up to achieving the constant weight. The average total dry matter was recorded (g/plant) genotype and replication wise.

Number of days required to 50% flowering

The day on which 50% plants from the plot found bloomed was noted and recorded. Thus, total number of days required for flowering of 50% plants, from date of sowing were counted and expressed as days to 50% flowering.

Results and Discution

Effect of seed priming on seed germination and germination percentage of chickpea

The seed germination of chickpea was influenced significantly. The significantly higher seed germination (251 per plot) of chickpea was recorded in seed priming with 0.5 % potassium nitrate for 4 hours. The lowest seed germination of chickpea (198 per plot) was recorded in control (no seed priming). The seed germination is higher in seed priming as compared to control. Also the germination percentage of chickpea crop was influenced significantly. Significantly higher germination percentage (89.6%) was recorded in seed priming with 0.5 % potassium nitrate for 4 hours. The lowest germination percentage (70.7%) were recorded in control (no seed priming).

The higher germination per plot and germination percentage in seed priming with 0.5 % potassium nitrate for 4 hours might be due to stimulated hypocotyl growth, increased cell elongation resulting in faster emergence and positive effect on germination. Similar observations were recorded by Choudhary *et al.* (2008) in chickpea, Golenzani *et* al. (2008), Patil *et.al* in chickpea and Selvarani *et al.* (2011) in onion.

Table 1. Effect of seed priming on germination of chickpea

Treatments	Germination per plot	Germination (%)
T1: Control (no seed priming)	198	70.71
T2: Seed priming with normal water for 4 hrs	233	83.33
T3: Seed priming with 0.5% urea for 4 hrs	239	85.48
T4: Seed priming with 1.0% urea for 4 hrs	241	86.07
T5: Seed priming with 0.5% Ammonium sulphate for 4 hrs	244	87.02
T6: Seed priming with 1.0% Ammonium sulphate for 4 hrs	242	86.55
T7: Seed priming with 0.5% potassium nitrate (13:00:45) for 4 hrs	251	89.64
T8: Seed priming with 1.0% potassium nitrate (13:00:45) for 4 hrs	249	88.81
T9: Seed priming with GA3 50 ppm for 4 hrs	239	85.24
T10 Seed priming with GA3 100 ppm for 4 hrs	244	87.14
T11: Seed priming with Chlormequate chloride 50 ppm for 4 hrs	241	86.07
T12: Seed priming with Chlormequate chloride 100 ppm for 4 hrs	240	85.60
S.E. (m)+	8.46	3.02
CD@5%	24.8	8.86

Table 2. Effect of seed priming on plant height (cm) 30, 60, 90 DAS

Treatment	30 DAS	60 DAS	90 DAS
T1: Control (no seed priming)	17.1	27.2	34.4
T2: Seed priming with normal water for 4 hrs	18.8	31.7	37.3
T3: Seed priming with 0.5% urea for 4 hrs	19.4	35.3	38.4
T4: Seed priming with 1.0% urea for 4 hrs	19.3	34.2	38.5
T5: Seed priming with 0.5% Ammonium sulphate for 4 hrs	19.0	34.7	37.5
T6: Seed priming with 1.0% Ammonium sulphate for 4 hrs	19.3	33.1	38.0
T7: Seed priming with 0.5% potassium nitrate (13:00:45) for 4 hrs	21.1	35.4	39.7
T8: Seed priming with 1.0% potassium nitrate (13:00:45) for 4 hrs	23.7	35.8	39.8
T9: Seed priming with GA3 50 ppm for 4 hrs	19.2	32.3	38.2
T10 Seed priming with GA3 100 ppm for 4 hrs	20.3	35.0	38.6
T11: Seed priming with Chlormequate chloride 50 ppm for 4 hrs	18.9	29.7	37.5
T12: Seed priming with Chlormequate chloride 100 ppm for 4 hrs	18.2	29.8	36.6
S.E. (m)+	1.125	1.8	0.803
CD@5%	3.3	5.51	2.36

Table 3. Effect of seed priming on number of branches

Treatment	30 DAS	60 DAS	90 DAS	At harvest
T1: Control (no seed priming)	2.3	6.3	10.0	10.3
T2: Seed priming with normal water for 4 hrs	2.3	7.3	12.0	12.0
T3: Seed priming with 0.5% urea for 4 hrs	2.7	7.7	12.7	12.7
T4: Seed priming with 1.0% urea for 4 hrs	3.0	7.0	12.3	12.7
T5: Seed priming with 0.5% Ammonium sulphate for 4 hrs	3.3	8.0	12.0	12.7
T6: Seed priming with 1.0% Ammonium sulphate for 4 hrs	3.7	8.3	12.7	12.7
T7: Seed priming with 0.5% potassium nitrate (13:00:45) for 4 hrs	4.3	9.3	14.0	14.0
T8: Seed priming with 1.0% potassium nitrate (13:00:45) for 4 hrs	5.7	11.7	14.3	14.3
T9: Seed priming with GA3 50 ppm for 4 hrs	3.7	8.3	13.7	13.7
T10 Seed priming with GA3 100 ppm for 4 hrs	3.7	8.3	12.7	13.0
T11: Seed priming with Chlormequate chloride 50 ppm for 4 hrs	5.3	10.0	14.0	14.0
T12: Seed priming with Chlormequate chloride 100 ppm for 4 hrs	3.7	9.3	13.0	13.0
S.E. (m)+	0.7	1.05	1.44	0.5
CD@5%	2.14	3.08	4.25	1.6

Table 4. Effect of seed priming on dry matter content (g) at 30, 60, 90 DAS

Treatment	30 DAS	60 DAS	90 DAS
T1: Control (no seed priming)	2.0	12.1	27.3
T2: Seed priming with normal water for 4 hrs	2.5	12.8	27.4
T3: Seed priming with 0.5% urea for 4 hrs	2.8	12.8	28.2
T4: Seed priming with 1.0% urea for 4 hrs	2.6	13.5	30.8
T5: Seed priming with 0.5% Ammonium sulphate for 4 hrs	2.7	13.6	30.9
T6: Seed priming with 1.0% Ammonium sulphate for 4 hrs	2.6	13.8	31.5
T7: Seed priming with 0.5% potassium nitrate (13:00:45) for 4 hrs	3.0	14.5	32.5
T8: Seed priming with 1.0% potassium nitrate (13:00:45) for 4 hrs	3.2	14.9	33.7
T9: Seed priming with GA3 50 ppm for 4 hrs	2.8	13.3	29.6
T10 Seed priming with GA3 100 ppm for 4 hrs	2.6	13.5	30.3
T11: Seed priming with Chlormequate chloride 50 ppm for 4 hrs	2.8	12.9	28.8
T12: Seed priming with Chlormequate chloride 100 ppm for 4 hrs	3.0	14.3	31.8
S.E. (m)+	0.201	0.545	1.244
CD@5%	0.59	1.6	3.65

Table 6. Effect of seed priming on number of days required for 50% flowering

Treatment	No of days required for 50% flowering
T1: Control (no seed priming)	50.6
T2: Seed priming with normal water for 4 hrs	49.7
T3: Seed priming with 0.5% urea for 4 hrs	49.0
T4: Seed priming with 1.0% urea for 4 hrs	50.0
T5: Seed priming with 0.5% Ammonium sulphate for 4 hrs	50.3
T6: Seed priming with 1.0% Ammonium sulphate for 4 hrs	45.3
T7: Seed priming with 0.5% potassium nitrate (13:00:45) for 4 hrs	46.0
T8: Seed priming with 1.0% potassium nitrate (13:00:45) for 4 hrs	45.7
T9: Seed priming with GA3 50 ppm for 4 hrs	45.0
T10 Seed priming with GA3 100 ppm for 4 hrs	45.0
T11: Seed priming with Chlormequate chloride 50 ppm for 4 hrs	50.0
T12: Seed priming with Chlormequate chloride 100 ppm for 4 hrs	50.3
S.E. (m)+	1.642
CD@5%	4.82

Effect of seed priming on height of chickpea

The plant height (cm) was recorded 30, 60, 90 DAS and data is presented in table 2. Data pertaining to plant height of chickpea revealed that seed priming with 1.0 % potassium nitrate for 4 hours showed significantly higher (23.7 cm) plant height at 30 DAS, (35.8cm) at 60DAS and (39.7cm) at 90DAS. The lowest plant height was recorded in control (no seed priming) i.e. 17.1cm, 27.2cm, 34.4cm at 30, 60, 90DAS respectively, plant height is important morphological parameter exhibiting direct relationship with grain yield. It is a visible measure of plant growth and is a function of leaf emergence and internodal elongation. Since leaves and branches born on stem, leaf area development and biomass production shows close relationship with plant height. The effect of seed priming on plant height showed rapid increase in plant height over no seed priming (control). The enhancement of chickpea plant primed with 1% potassium nitrate might be due to increased cell division and seedling roots. Similar observations were recorded by Hamidi and Anosheh (2013) and Patil *et al.* in chickpea and Ahmadanad *et al.* (2012) in soybean.

Effect of seed priming on number of branches of chickpea

The number of branches was recorded at 30, 60, 90 DAS and at harvest of chickpea. The data is presented in table 3. The data recorded number of branches significantly higher in seed priming with 1.0% potassium nitrate for 4 hours (5.7) at 30DAS, (11.7) at 60DAS, (14.3) at 90DAS and (14.3) at harvest. The lowest number of branches recorded in control (no seed priming) and seed priming with normal water for 4 hours. The treatment seed priming with 1% potassium nitrate showed significantly higher number of branches by 38.8% over control. Similarly increase in number of branches of potassium primed were observed by Harris *et al.* (1999) in chickpea.

Effect of seed priming on dry matter content of chickpea

The dry matter content of chickpea was recorded at 30, 60 and 90 DAS. The data pertaining to dry matter content of chickpea reported in table 4.The dry matter content of chickpea was significantly increased due to seed priming treatment for 4 hours over control (no seed priming). Significantly higher dry matter content of chickpea (3.2gm) at 30 DAS, (14.9gm) at 60DAS, (33.7gm) at 90DAS was recorded in seed priming with 1.0% potassium nitrate for 4 hours. Lowest dry matter content of chickpea (2.0gm) at 30DAS, (12.1gm)at 60DAS, (27.3gm) at 90 DAS was recorded in control (no seed priming).

Plant dry matter content is the consequence of plant physiological and biological activity. Result of plant dry matter content of different seed priming treatments were found significant at 30, 60 and 90DAS. The highest dry matter content was recorded in seed priming with potassium nitrate for 4 hours. Similar observations were recorded by Ahmadavant *et al.* (2012) in soybean and Patil *et al.*(2018) in chickpea.

Effect of seed priming on number of days required for 50% flowering

The number of days required to attain 50% flowering was reduced with priming treatments. Seed priming with 100ppm GA_3 for 4 hours induced flowering (45 days) early by 5.6 days compared to control (50.6 days). The early flowering may be due to higher endogenous level of GA_3, early completion of vegetative growth and better nourishment of plants. Similar observations in advancement of flowering were reported by Khairul *et al.* (2015) in chickpea and Beedi *et al.* (2017) in chickpea.

Conclusion

Different seed priming treatments significantly improved morpho-physiological parameter. Amongst the eleven different seed priming treatments, seed priming with 0.5% potassium nitrate for 4 hours recorded significantly highest field emergence, germination percentage, and seed priming with 1% potassium nitrate for 4 hours was recorded significantly highest plant height, no. of branches, dry matter content.

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Heterosis and Combining Ability Studies in Chickpea (*Cicer arietinum* L.)

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Abstract: The present study entitled **"Heterosis and combining ability Studies in chickpea (*Cicer arietinum* L.)"** was carried out with objectives to study the heterosis and combining ability effects in different genotypes of chickpea using Line x Tester analysis.

The crosses were made using four lines (females) viz., PDKV Kanchan, Phule Vikram, Chanoli and AKG-1303 and Six males (testers) *viz.*, GAU-1107, GJC-3, WR-315, JCP-101, C-1821 and GJG-0814. All the 24 crosses along with the variety 'JAKI-9218' as standard check have been evaluated in randomized block design with two replications at the pulses research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *rabi*-2019. The data was recorded on characters viz., Plant Stand, days to 50 per cent flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, 100 seed weight, seed yield per plant, number of seeds per pod, number of empty pods per plant. The highest mean performance was recorded in PDKV Kanchan x GJG-0814 (27.65g) followed by Phule Vikram x C-1821 (26.50g) and AKG-1303 x JCP-101(26.35g) for yield per plant. The highest and significant average heterosis for yield per plant was recorded by cross combination PDKV Kanchan x GJG-0814 (25.68%) followed by Phule Vikram x GJC-3 (23.08%). The maximum significant heterobeltiosis for yield per plant was recorded by the cross PDKV Kanchan x GJG-0814 (20.22%). The highest standard heterosis over check JAKI-9218 for seed yield per plant was recorded by PDKV Kanchan x GJG-0814 (15.45%). Among the parents three lines (PDKV Kanchan, AKG-1103 and Phule Vikram) and tester (JCP-101) were found to be good general combiners for yield per plant along with the most of the yield contributing traits. Thus these parents should be included in further hybridization programme. High sca effects for yield per plant were recorded by PDKV Kanchan x GJG-0814 (5.01) followed by AKG-1303 X JCP-101 (4.80) and Phule Vikram X GJC-3 (3.14). These crosses also recorded the sca effects for most of the yield contributing traits. On the basis of mean performance, heterosis and sca effects of crosses, three crosses viz., PDKV Kanchan x GJG-0814, AKG-1303x JCP-101, Phule Vikram x JGC-3 were identified as promising crosses for seed yield per plant.From the present study,the genotype PDKV Kanchan, AKG-1303, Phule Vikram , and JCP-101 were identified as best combiners for yield and other yield contributing traits. Also,the genotype GJG-0814 was identified as best combiner for number of pods per plant. Hence it is concluded that these parents should be exploited for development of high yielding genotypes in chickpea.

Key words: Heterosis, Combining ability, Line x Tester analysis.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crop all over the world covering various parts of Asia, Africa, Europe, Australia and South America and North America continents. It becomes an integral part of the cropping system of the farmers all over the world because this crop fits well in the crop rotation and crop mixture followed by them. Chickpea is grown in tropical, subtropical and temperate region. It contributes for 75% of total production in the world. Chickpea ranks third in pulse crop after dry bean and dry pea with production of about 913 kg/ha (FAO 2012).In Maharashtra 2017-18 area was 20.00 lakh ha, production 17.84 lakh tones and productivity 892 kg/ha. In Vidarbha 2017-2018, the area of chickpea was 6.31 lakh ha with production 5.59 lakh tones and productivity 955 kg/ha. (District Wise General Statistical Information of Agricultural Dept. (M.S.) Part II 2014-15/2018-19).

The study of combining ability helps in isolating useful parental lines and desirable specific cross combinations which could be further exploited in development of improved varieties. Estimation of heterosis will help in identifying genetically potential crosses for further exploitation.

Material and Methods

The experiment consisted of 24 F_1's crosses, 10 parents and one check. The female parents (lines) were PDKV Kanchan,Phule Vikram,AKG-1303, andChanoli. The male parents (Testers) were GAU-1107, GJC-3,WR-315,JCP-101,C-1821 and GJG-0814. Tthe check used in study was JAKI-9218. The set of 24 hybrids were developed during *Rabi* of 2018-2019 by pollinating four female lines with six male parents in line x tester fashion at Pulses Research Unit, Dr.PDKV, Akola.

The total 24 chickpea hybrids along with 10 parents and one check JAKI-9218 in two replications were grown during *Rabi* of 2018-19 at Pulses Research Unit, Dr.PDKV, Akola. One row each of P_1, P_2 and F_1 were grown in randomized block design with two replications. Data were recorded on five randomly selected plants from each row excluding border plants. Each row consisted of 3 m length and row to row and plant to plant distance was kept 45 cm and 10 cm, respectively. All the agronomic practices were followed to raise a good crop.Observations were recorded on different quantitative characters and data was analyzed as per line x tester mating design.

Results and Discussion

The present investigation was undertaken with a view to explore the possibility of exploiting heterosis and to find out the combining ability of parents and crosses using principles and techniques of biometrical genetics in a line x tester mating design, involving four female and six male parents.

Heterosis

In the present investigation, heterosis is calculated over mid parent, better parent (heterobeltiosis) and standard heterosis (over check JAKI -9218).

For plant height out of 24 crosses, no any cross exhibited highly positive significant heterosis over mid parent, better parent and standard check.

As regards, primary branches per plant eleven, eight, sixteen crosses exhibited highly positive significant heterosis over mid parent, better parent and standard check JAKI-9218 respectively. Highest magnitude of mid parent for this trait was expressed by the crosses PDKV Kanchan × GJC-3 (54.84%) and PDKV Kanchan x WR-315 (45.74%). Maximum positive significant better parent heterosis was recorded by PDKV Kanchan × GJC-3 (45.45%) and PDKV Kanchan x WR-315 (42.42). Highest standard heterosis for this trait was expressed by the crosses Chanoli × JCP-101 (87.04%) and PDKV Kanchan x GJC-3 (77.78%) over the check JAKI-9218. In respect of secondary branches per plant out of 24 crosses, only two crosses, Phule Vikram × C-1821 (42.49%) and PDKV Kanchan x C-1821 (13.13%) showed highly positive significant heterosis over mid parent. Phule Vikram × C-1821 (30.21%) showed maximum positive significant heterosis over better parent. Highest standard heterosis for this trait was expressed by the crosses Phule Vikram × C -1821 (33.77%) over the check JAKI-9218. For number of pods per plant, out of all the 24 crosses, seven crosses exhibited positive significant mid parent heterosis. The cross Chanoli × GAU-1107 (21.81) and Chanoli x JCP-101 (17.57) showed the highest positive significant mid parent heterosis. The cross PDKV Kanchan x GJG-0814 (14.21) and Chanoli x GAU-1107 (12.89) showed better parent heterosis. The cross PDKV Kanchan × GJG-0814 showed highly significant standard heterosis over check JAKI-9218. For number of seeds per pod only one cross Chanoli × WR-315 (20%) showed positive significant heterosis over mid parent and better parent. None of the cross exhibited significant positive standard heterosis over standard check JAKI-9218 for this trait.

Seed yield, the complex character decides the economic worth of the crosses. The cross PDKV Kanchan × GJG-0814 (25.68%), Phule Vikram x GJC-3 (23.08%) showed highly positive significant heterosis over mid parent. None of the crosses exhibited positive significant standard heterosis over JAKI-9218. The highly positive significant heterobeltiosis was recorded in the cross PDKV Kanchan × GJG-0814 (20.22%). Weight of 100 seed is often considered as one of the yield component in chickpea. None of the cross exhibited positive significant better parent heterosis over check JAKI-9218 for this trait. The cross Phule Vikram x C-1821 (13.36%) exhibited highly positive significant heterosis over mid parent and the cross Phule Vikram x C - 1821 (20%), PDKV Kanchan x GJG-0814 (16.10%) exhibited standard heterosis over check. In respect of number of empty pods per plant none of the crosses exhibited negative significant heterosis over mid parent and standard check. Highest magnitude of heterobeltiosis for this trait was expressed by the crosses Chanoli x WR - 315 (-63.93%) and Chanoli x C - 1821 (-63.93%).

Combining Ability

The knowledge of combining ability is a prerequisite to isolate the best specific combination and to study the combining ability of the parents with diverse genetic background. The gca effect is controlled by fixable additive genes and high gca would produce transgressive segregates in F_2 or latter generation. None of the parents recorded the significant gca in desirable direction simultaneously for all characters. However, Phule Vikram, PDKV Kanchan, AKG -1303 among the lines and JCP-101 among the testers were found to possess significant gca effects for most of the yield contributing characters. Hence, these genotypes found to be good general combiners among the available genotypes.

Specific combining ability effects are indicative of heterosis. Similarly, they represent both dominant and epistatic gene actions (Sprague and tatum, 1942). Specific combining ability is directly related to heterosis.

Among the 24 F_1's two crosses exhibited positive significant sca effects for seed yield per plant. The hybrid PDKV Kanchan × GJG-0814 exhibited highest significant sca effects for seed yield per plant followed by AKG-1303 × JCP-101 and Phule Vikram x GJC-3 exhibited positive sca effect for seed yield per plant. The sca effects of hybrids indicated that two crosses PDKV Kanchan x GJG-0814, AKG-1303 x JCP-101 were found to have significant sca effects for grain yield per plant. The cross PDKV Kanchan x GJG-0814 was good specific combiners for grain yield per plant in addition to its component characters like number of pods per plant, 100 seed weight, and number of seeds per pod. AKG-1303 x JCP-101 was good combiners for pods per plant and number of seeds pod. Though the three crosses visually Phule Vikram × GAU-1107, AKG-1303 × GAU-1107 and Chanoli × JCP-101 show positive sca effects for seed yield per plant, these crosses does not able to produce high positive standard heterosis may be due to the high x low gca effects of the parent involved in these four crosses. This indicates that only having high positive sca effects for seed yield does not give high mean seed yield per plant along with high standard heterosis. These crosses *viz.*, Phule Vikram × GAU-1107, AKG-1303 × GAU-1107 and Chanoli × JCP-101 showed positive sca effects for seed yield per plant, but in these crosses high sca is not associated with positive heterosis so these three crosses will not be suitable for exploitation of heterois

Table : Mean yield performance, standard heterosis, gca and sca of the promising crosses

Sr. No	Crosses	Mean seed yield / plant(g)	Average heterosis (H_1)	Heterobeltiosis (H_2)	Standard heterosis (H_{3A})	Significant (H_{3A}) for other characters	SCA effect	GCA effects of parent
1	PDKV Kanchan x GJG-0814	27.65	25.68**	20.22*	15.45	7,8	5.01**	3.56**x0.33 HL
2	AKG-1303 x JCP-101	26.35	19.37*	13.58	10.02	3	4.80**	2.29**x1.12 HH
3	Phule Vikram x GJC-3	25.97	23.08**	15.68	8.43	3	3.14	3.90x0.18HL

Note: * Significant at 5% level of significance **Significant at 1% level of significance

H : High GCA, L : Low GCA

P_1 and P_2 : Female parent and male parent of the crosses respectively

1: Plant stand 2: Days to 50 % flowering

3: Days to maturity 4: Plant height (cm)

5: No. of primary branches per plant 6: No. of secondary branches per plant

7: No. of pods per plant 8: 100 seed weight (g)

9: Seed yield per plant (g) 10: No. of seeds per pod

11:No. of empty pods per plant

On the basis of mean seed yield performance, standard heterosis, gca and sca effects for seed yield, three crosses were identified as promising crosses (Table 4.10). The cross PDKV Kanchan × GJG-0814 recorded highest seed yield per plant (27.65g), highest standard heterosis (15.45%), highly significant sca effect (5.01) and high x low gca effects of parents, whereas, the cross AKG-1303 × JCP-101 has recorded second highest mean seed yield per plant (26.35g), standard heterosis (10.02%) and highly significant sca effect (4.80) with high x high gca effect of the parents. The cross PhuleVikram × JGC-3 showed high mean seed yield per plant (25.97g), standard heterosis (8.43%) along with highly significant sca effect (3.14) and having high x low gca interaction of parents. Such high gca x high gca effects for parents indicates additive type of interaction between parents for the expression of the characters. Though single plant selection should be practiced in advanced segregating generation to isolate pureline from such combinations. Similar results were observed by Singh (1979), Mishra and Yadav (1974).

Out of best three promising crosses, the cross PDKV Kanchan × GJG-0814 which ranked first for seed yield and also recorded the highest number of pods per plant (115.35), with highly significant standard heterosis. The cross AKG-1303 × JCP-101 has been identified as most promising as it shows highest general combining ability of both the parents involved. The cross Phule Vikram × GJC-3 which ranked 3rd for seed yield has also recorded the highest number of pods per plant (109.25), highly significant standard heterosis as well as sca effects for plant stand, early maturity, and number of seeds per pod. Hence, the top three crosses *viz.*, PDKV Kanchan × GJG - 0814, AKG-1303 × GCP-101 and Phule Vikram × GJC-3 were identified as promising crosses for seed yield. Thus, these crosses need further evaluation in segregating generation for identification of high yielding genotypes of chickpea.

Conclusion

On the basis of mean yield performance, standard heterosis, gca and sca effects three crosses were identified as promising crosses which are PDKV Kanchan × GJG-0814, AKG-1303 × JCP-101, Phule Vikram × GJC-3. These crosses were found to be promising for seed yield per plant and other yield contributing characters may produce desirable transgressive segregants in advance generation.

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Population Dynamics of Fall Armyworm *Spodoptera frugiperda* and its Natural Enemies on Maize

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Abstract: Investigations on "Population dynamics Fall Armyworm *Spodoptera frugiperda* of maize and their natural enemies" were conducted during *Kharif*, 2019-20 on the research field of Department of Agril. Entomology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola on the plot size 200 sq.mt area.

The incidence of fall armyworm and natural enemies were recorded after noticing the initial infestation and continued up to the maturity of the crop at weekly intervals (7 days) throughout the growing season.

Investigations was made on infestation of fall armyworm *Spodoptera frugiperda* and its natural enemies *viz*., spiders, ladybird beetle, carabid larvae, and correlations were made with weather parameters *viz*., Maximum temperature, minimum temperature, sunshine hours, morning RH at 7 AM, evening RH at 2 PM and total rainfall. The infestation of fall armyworm initiated from 29th Standard meteorological week and reached its peak (45.0%) infestation during 31st standard meteorological week. Natural enemies, spider and ladybird beetle populations were found to be reached their peak viz., (0.85) and (1.0) number per plant respectively, during 38th standard meteorological week while carabid larvae population was found to be reached its peak as (0.25) number per plant during 32th standard meteorological week. Minimum temperature and sunshine hour exerted significant positive impact on the infestation of fall armyworm, while, maximum temperature had significant positive association with infestation of fall armyworm. Positive correlation was found between fall armyworm and its natural enemy population i.e. carabid larvae. The population of natural enemies i.e. spider and ladybird beetle were found to be significant positive correlation with morning relative humidity, while, maximum temperature had significant negative impact on ladybird beetle population. The abiotic factors of the environment did not show any significant influence on population of carabid larvae. Thus, present studies concluded that weather factor determines the seasonal activity and population build-up of fall armyworm and its natural enemies on maize crop. The correlation studies clearly show the importance of weather parameters in predicting the insect pest incidence and these studies will be definitely helpful to farmers and extension workers for developing efficient pest management strategies for sustainable maize production.

Key words: Fall armyworm, natural enemies, weather parameters, abiotic factors

Introduction

In India, Maize is grown throughout the year. It is predominantly a kharif crop with 85 per cent of the area under cultivation in the season. In India, it is the third important cereal crop after rice and wheat that provides food, feed and fodder. It accounts for around 10 per cent of total food grain production in the country. In addition to staple food for human being and quality feed for animals, maize serve as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. Major maize growing states are Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Bihar, Uttar Pradesh, Telangana, Gujarat and Tamil Nadu.

The average productivity in India 109 Kg / ha is much less than the U.S. 863Kg / ha in spite of increasing in the area under this crop. The productivity is still very low which may be due to several reasons viz, environmental factor, low mechanization, pest and diseases etc. insect pest are one of the major limitations of low yield of maize. The insect pest of maize of inflicts serious losses both directly as borer, sap suckers, stem and root feeders etc. and directly as vectors to some diseases.

The Fall Armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: *Noctuidae*) is native to the Americas and it is key pest of maize (*Zea mays* L.). *S. frugiperda* has been reported for the first time in 2018 in Africa, in Nigeria, Sao Tome in Benin and Togo causing significant damages to maize and it has great potential for further spread and economic damage. It has since spread to 28 countries in Africa. In 2018, it began to spread widely in India (Decle and Paul, 2018). In India, *Spodoptera frugiperda* is recently reported in Karnataka Tamilnadu and Telangana infesting maize crop. It is also found in Maharashtra of Solapur and district. (Sisodiya *et al.* 2018). Also, Chormule *et al.* (2019) identified on molecular basis that the insect pest creating the menace on maize is *Spodoptera frugiperda* and also reported in the month of September its feeding on two months old sugarcane crop, variety (Co 86032) at Ghogaon village of Sangli District (Maharashtra).

Fall army worm feeds on all growth stages of maize but most frequently in the whorl of young plant up to 45 days old. Larvae usually consume a large amount of foliage and sometimes destroy the growing point of the plant. Yield reductions in maize due to feeding of the fall armyworm have been reported as high as 34%. (Deole and Paul, 2018).

Looking to the above literature cited the menace of the *Spodoptera frugiperda* reported by the authors in the recent past; the study on Population dynamics of major insect pests of maize have been carried out.

Objectives

- To study the abundance of *Spodoptera frugiperda* of maize and their natural enemies.
- To develop correlation coefficients between *Spodoptera frugiperda* and their natural enemies with the existing weather parameters.

Material and Methods

Materials

The material use during the research consists of land, various agricultural implements required for preparatory tillage, sowing and intercultural operation, seeds of maize, fertilizers, tape, rope, tags, lens, pair of bullocks, labour, threads and fencing etc. have been provided by the Department of Agril. Entomology Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Methods

Details of experiment

The details of experiment are given below.

1	Crop	:	Maize
2	Variety	:	UDAY (Mahabeej 1114)
3	Design of experiment	:	
4	Plot size	:	
5	Spacing a) Row to Row b) Plant to Plant	 : :	 60 cm 20 cm
6	Seed rate	:	15-20 kg/ha
7	Fertilizer	:	120:60:30 NPK kg/ha
8	Date of sowing	:	5 July 2019
9	Date of emergence	:	11 July 2019
10	Method of sowing	:	Dibbling

Method of observation

Maize in the area of 200sq.mt was divided into four equal quadrates. In each quadrate ten plants were randomly selected for each observation and data were recorded with regard to the incidence of insect pests and their natural enemies at weekly interval (7 Days). The observation of fall armyworm was recorded as per the procedure described below.

Fall armyworm

Examine and counts the plant for fall army worm damage i.e. leaves eaten from margin towards midrib, larvae in the central whorl of leaves with excreta and workout the per cent plant infested by fall army worm.

Data on natural enemies were collected in the observational sites as mentioned below:

Parasitoids: Five samples of pest stages from each quadrate were collected and were brought to the laboratory. These pest stages were observed for parasitization if any and per cent parasitization were calculated.

Predators: Predators like coccinellids, carabid larvae and spiders were counted at weekly intervals on 5 randomly selected plants in each quadrate.

The populations of insect pests, parasites and predators were correlated with weather parameters namely maximum temperature, minimum temperature, RH (morning and evening) and total rainfall. The periodicity of observations at weekly intervals was planned as per the standard weeks during the entire crop season. Correlation coefficients between pest population densities and abundance of their natural enemies in the background of existing weather parameters during the period of experimentation were worked out.

Statistical analysis

The influence of abiotic factors on the occurrence of stem borer, fall armyworm, aphid and their natural enemies of maize were statistically analyzed by subjecting the number of insects per plant and weather data to simple correlation (Gomez and Gomez, 1984).

Meteorological data

The weekly meteorological data recorded on maximum and minimum temperature, sunshine hours, relative humidity (at. 7 am and 2 pm) and total rainfall and of Agro-meteorological weeks during the course of this field experimentation were recorded.

Results and Discussion

To study the abundance of major pests of maize and their natural enemies

The occurrence of the of maize insect pest namely fall armyworm was recorded between 28th standard meteorological week to 39th standard meteorological week which initiating from 29th SMW to 39th SMW at weekly intervals during *kharif* 2019. The natural enemy fauna associated with the fall armyworm were namely spiders, coccinellids, and carabid larvae were also estimated for their abundance in the field.

Population dynamics of fall armyworm (*Spodoptera frugiperda*)

The incidence of fall armyworm first appeared in 29th SMW and last up to the 38th SMW during 2019 on maize. The incidence of fall armyworm initiated in 29th SMW with (12.5%) infestation. The pest infestation increased gradually and reached its peak during 31th SMW with (45%) infested plants (Table 1). Thereafter, pest infestation reduced gradually from 32nd SMW with (15%) damage plants and onwards the population started declining and reached to its minimum (5%) infested plants on 36th to 38th SMW and there was no infestation observed on 39th SMW. On perusal of the data obtained on abundance of the fall armyworm in terms of per cent plant infestation indicated a clear peak during 31th SMW. The weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 31.6°C, 20.9°C, 4.7hrs, 88 per cent, 69 per cent and 106.1 mm, respectively.

The findings of the present investigation of fall armyworm infestation are in close confirmation with those of the following Researchers viz., Chormule *et al.*, (2019) who reported that FAW incidence on maize was up to 60 days and there after it gets reduced. Djaman *et al.* (2019) also reported the peak infestation of fall armyworm in the month of August during *kharif* season of 2016, 2017 and 2018. Sundar *et al.*, (2018) reported that the infestation of *Spodoptera litura* started at 28 DAG, (2nd week of August) and peak infestation was during the last week of August, thereafter infestation abruptly decreased after 84 DAG. Murua *et al.* (2006) reported that larval populations of fall armyworm are more stable throughout the vegetative phase and decrease during beginning of the reproductive phase of corn.

Table 1: Per cent infestation of FAW on maize in relation to weather factors

Sr. No	SMW	Month and Week	% Infestation	Weather factors					
				Max. Temp (°C)	Min. Temp (°C)	Sunshine hours	Morn. RH (%)	Eve. RH (%)	Total Rainfall (mm)
1	28	July-II	0	30.2	20	0.7	89	68	53.8
2	29	III	12.5	33.5	21.5	4.5	78	49	22.4
3	30	IV	40	34.9	21.8	7.1	79	48	27.3
4	31	Aug-I	45	31.6	20.9	4.7	88	69	106.1
5	32	II	15	27.6	19.6	0.7	92	82	118.7
6	33	III	15	29.9	20.1	2.2	90	73	79
7	34	IV	12.5	30.5	20.1	4.2	88	67	10.9
8	35	V	10	29.6	20	3.1	90	76	28.5

Sr. No	SMW	Month and Week	% Infestation	Weather factors					
				Max. Temp (°C)	Min. Temp (°C)	Sunshine hours	Morn. RH (%)	Eve. RH (%)	Total Rainfall (mm)
9	36	Sep-I	5	29.1	19.9	3.3	91	72	54.5
10	37	II	5	29.6	20.6	1.9	92	77	9
11	38	III	5	29	19.9	1.7	90	75	18.5
12	39	IV	0	30.3	19.4	2.8	94	70	118.1

Population dynamics of natural enemies

The data obtained on the natural enemy populations on maize indicated that no spider was found during 28th SMW to 31th SMW and started increasing in numbers (0.1) number of spiders per plant in 32th SMW and fallowed by 33th SMW (0.15) number of spiders per plant. The abundance of these predators increased with the crop age along with corresponding increase in pest population. The natural enemy population of spider reached its peak during 38th SMW with (0.85) number of spiders per plant. However, on 39th SMW population decreased with (0.7) number of spiders per plant. On perusal of the data obtained on abundance of the spider in terms of average number of spiders per plant indicated a clear peak during 38th SMW (Table 2). The weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 29°C, 19.9°C, 1.7hrs, 90 per cent, 75 per cent, 18.5 mm, respectively.

The data obtained on the natural enemy populations indicated that no ladybird beetle (Adult and grub) was found during 28th to 31th SMW and started increasing in numbers, (0.2) number of LBB per plant in 32th SMW. The abundance of these predators increased with the crop age along with corresponding increase in pest population. The natural enemy population of LBB reached its peak during 38th SMW with (1.0) number of LBB per plant. However, on 39th SMW the population decreased (0.65) number of LBB per plant. On perusal of the data obtained on abundance of the LBB in terms of number of LBB per plant indicated a clear peak during 38th SMW. The weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 29°C, 19.9°C, 1.7hrs, 90 per cent, 75 per cent, 18.5 mm, respectively.

Data obtained on the natural enemy populations indicated that no carabid larvae was during 28th SMW to 30th SMW and started increasing in numbers (0.1) number of carabid larvae per plant in 31th SMW. The natural enemy population of carabid larvae reached its peak during 32th SMW with (0.25) number of carabid larvae per plant (Table 2). However, from 33th SMW onwards the population started declining with (0.2) number of carabid larvae per plant fallowed by 34th SMW with (0.1) number of carabid larvae per plant and reached to its minimum (0.00) number of carabid larvae per plant from 35th SMW to 39th SMW. On perusal of the data obtained on abundance of the carabid larvae in terms of number of carabid larvae per plant indicated a clear peak during 32th SMW. The weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 27.6°C, 19.6°C, 0.7hrs, 92 per cent, 82 per cent, 118.7 mm, respectively.

Present results are in agreement with those of the Researchers viz., Kore *et al.* (2013) who also reported that the predator lady bird beetle was active in the month of September and October. Similar observations were also supported by Andreas *et al.* (1999) concluded that beetles and spiders were the dominant predators of insect pests of maize and confirmed that ground beetles and spiders may play an important role in controlling herbivore populations in maize fields. Patra *et al.* (2013) who reported that total twenty-four insect pests and some natural enemies including seven coccinellid beetles and two predatory bugs and thirteen spider species were recorded in maize. Sahito *et al.* (2012) reported that in case of predators, the big-eyed bug was recorded (1.27) followed by seven spotted ladybird beetles (0.44), zigzag beetle (0.69), eleven spotted beetles (0.07), *Brumus* (0.50), green lacewing (0.78) per plant, respectively. Krish *et al.* (2006) reported that high abundance of spider and ground beetle (Carabidae) was associated with lowered population of fall armyworm throughout the maize vegetative cycle.

Table 2: Activity of natural enemies in relation to weather factors in maize

Sr. No	SMW	Month and Week	Predators			Weather factors						
			No. of spiders/plant	No. of grubs and adults of LBB/plant	No. of Carabid larvae/ plant	Max. Temp (°C)	Min. Temp (°C)	Sunshine hours	Morn. RH (%)	Eve. RH (%)	Total Rainfall (mm)
1	28	July-II	0	0	0	30.2	20	0.7	89	68	53.8
2	29	III	0	0	0	33.5	21.5	4.5	78	49	22.4
3	30	IV	0	0	0	34.9	21.8	7.1	79	48	27.3
4	31	Aug-I	0	0	0.1	31.6	20.9	4.7	88	69	106.1
5	32	II	0.1	0.2	0.25	27.6	19.6	0.7	92	82	118.7
6	33	III	0.15	0.4	0.2	29.9	20.1	2.2	90	73	79
7	34	IV	0.45	0.55	0.1	30.5	20.1	4.2	88	67	10.9
8	35	V	0.6	0.7	0	29.6	20	3.1	90	76	28.5
9	36	Sep-I	0.65	0.75	0	29.1	19.9	3.3	91	72	54.5
10	37	II	0.8	0.8	0	29.6	20.6	1.9	92	77	9
11	38	III	0.85	1	0	29	19.9	1.7	90	75	18.5
12	39	IV	0.7	0.65	0	30.3	19.4	2.8	94	70	118.1

Correlation coefficients of fall armyworm *Spodoptera frugiperda* with biotic and abiotic factors in maize during *Kharif*, 2019.

Correlation coefficient study (Table 3) revealed that the biotic factor *i.e.* carabid larvae (r = 0.251) was found to be positive which indicated that as fall armyworm population increases the population of predator also increases. In case of correlations between abiotic factors with per cent infestation of fall armyworm, it was found that the infestation was positively significant with maximum temperature (r = 0.581*), minimum temperature (r = 0.661*) and sunshine hours (r = 0.701*). It indicated that as the maximum temperature, minimum temperature and sunshine hours increases, the pest infestation also increased. However, pest infestation had non-significant positive correlation with total rainfall (r = 0.158) and non-significant negative correlation with morning relative humidity (r = -0.507) as well as evening relative humidity (r = -0.410).

The results of the present studies are in confirmation with findings of Kumar *et al.*, (2020) who reported that maximum and minimum temperature had positive impact on infestation of fall armyworm while morning relative humidity, evening relative humidity and total rainfall had negatively correlated with the pest incidence.

Hemchandra and Singh (2007) reported that higher temperature, lower relative humidity, lower total rainfall, longer duration of sunshine hours and higher wind speed seem to favour the pest population build up.

Krish *et al.*, (2006) reported that high abundance of spider and ground beetle (Carabidae) was associated with lowered population of fall armyworm throughout the maize vegetative cycle.

Table 3: Correlation coefficient of fall armyworm, *Spodoptera frugiperda* with biotic and abiotic factors in maize during *Kharif*, 2019.

Biotic factor	% Infestation of fall armyworm
Carabid larvae	0.251
Abiotic factors:	
Maximum. Temp (°C)	0.581*
Minimum Temp (°C)	0.661*
Sunshine hours	0.701*
Morning RH (%)	-0.507
Evening RH (%)	-0.410
Total Rainfall (mm)	0.158

*: Significant at P=0.05 **: Significant at P=0.01

Correlation coefficients between spiders and weather factors on maize during *Kharif*, 2019.

The correlation coefficient was worked out between population of spider population and abiotic factors (maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity and total rainfall). The spider population was positively significant with morning relative humidity (r = 0.590*) (Table 4). It indicated that as the morning relative humidity increases, spider population was also increased. However, positively non-significant correlation between evening relative humidity (r = 0.504) and spiders population. While, maximum temperature (r = -0.507), minimum temperature (r = -0.506), sunshine hours (r = -0.283) and total rainfall (r = -0.282) had non-significant negative influence on spider population. Thus, the data from Table clearly indicated that the morning relative humidity influence on population fluctuation of spider while, other weather parameters had no or less influence on population of Spider during *kharif* 2019.

The present findings are more or less tallies with the findings of Kumar *et al.*, (2020) who reported that significant positive correlation with maximum relative humidity, minimum relative humidity and rainfall with the population of spider. In the present findings, except rainfall, rest of the abiotic factors exerted the same association, but were non-significant. It might be due to variation of location and different environment conditions or variety or plant age on which investigation was carried out. Similarly, Patra *et al.*, (2013) who reported thirteen spider species in maize crop.

Table 4: Correlation coefficient between spider population and weather factors in maize during *Kharif*, 2019.

Weather parameters	Spiders per plant
Maximum. Temp (°C)	-0.507
Minimum Temp (°C)	-0.506
Sunshine hours	-0.283
Morning RH (%)	0.590*
Evening RH (%)	0.504
Total Rainfall (mm)	-0.282

*: Significant at P=0.05 , **: Significant at P=0.01

Correlation coefficients between ladybird beetle and weather factors in maize during *Kharif*, 2019.

Experiment carried out and correlations were drawn between weather parameters with respective number of ladybird beetle per plant (Table 5), it was found that the predation was found to be in negative and significant correlation with maximum temperature (r = -0.586*). While, morning relative humidity (r = 0.611*) had positively significant correlation with population of ladybird beetle. Minimum temperature (r = -0.557), Sunshine hours (r = -335) and total rainfall (r = -0.281) had negatively correlated but there was no significant impact. Positive but non-significant association of evening relative humidity (r = 0.572) with population of lady bird beetle was observed.

Thus, the data from Table clearly indicated that the maximum temperature and morning relative humidity influence on population fluctuation of ladybird beetle while, other weather parameters had no or less influence on population of ladybird beetle during *kharif* 2019. The present finding more or less tallies with the finding of Kumar *et al.*, (2020) who reported that maximum and minimum temperature had negative effect on abundance of lady bird beetle while maximum relative humidity and minimum relative humidity had a significant positive correlation with population of ladybird beetle.

Table 5: Correlation coefficient between ladybird beetle and weather factors

Weather factors	No. of grubs and adults of LBB/plant
Maximum. Temp (°C)	-0.586*
Minimum Temp (°C)	-0.557
Sunshine hours	-0.335
Morning RH (%)	0.611*
Evening RH (%)	0.572
Total Rainfall (mm)	-0.281

*: Significant at P=0.05, **: Significant at P=0.01

Correlation coefficients between carabid larvae and weather factors in maize during *Kharif*, 2019.

When correlations were drawn between weather factors with respective number of carabid larvae per plant (Table 6), it was found to be non-significant correlation with weather parameters. Among the weather parameters under study, there was positively non-significant association between total rainfall (r = 0.541), morning relative humidity (r = 0.233) and evening relative humidity (r = 0.338) and number of carabid larvae per plant. Maximum temperature (r = -0.368), minimum temperature (r = -0.256) and sunshine hours (r = -0.272) had non-significant negative influence on carabid larvae population (Figure 4.10). From the above data it is indicated that there was no significant impact of weather parameters with population of carabid larvae.

Table 6: Correlation coefficient between carabid larvae and weather factors in maize during kharif,2019.

Weather factors	No. of Carabid larvae/plant
Maximum. Temp (°C)	-0.368
Minimum Temp (°C)	-0.256
Sunshine hours	-0.272
Morning RH (%)	0.233
Evening RH (%)	0.388
Total Rainfall (mm)	0.541

*: Significant at P=0.05, **: Significant at P=0.01

Summary and Conclusions

The incidence of fall armyworm was first noticed at 29th SMW (3rd week of July 2019) and up to the 38th SMW (3rd week of September 2019). The pest infestation reached its peak during 31th SMW (1st week of August 2019) with (45%) infested plants and minimum (5%) infestation on 36th SMW.

Population dynamics of natural enemies

Spider population was first appeared on 32th SMW (2nd week of August 2019) and its peak i.e. 0.85 spiders per plant during 38th SMW (3rd week of September 2019) and minimum i.e. 0.7 spiders per plant during 39th SMW (4th week of September 2019).

Ladybird beetle population reached its peak i.e. 1.0 per plant during 38th SMW (3rd week of September 2019) and minimum i.e. 0.65 LBB per plant during 39th SMW (4th week of September 2019).

Carabid larvae population was first noticed on 31th SMW (1st week of August 2019) and reached its peak (0.25/per plant) during 32th SMW (2nd week of August 2019).

Fall armyworm infestation was positively significant with maximum temperature, minimum temperature and sunshine hours. However, pest infestation had non-significant positive correlation with total rainfall and non-significant negative correlation with morning relative humidity as well as evening relative humidity.

Correlation coefficient between natural enemies of pests of maize and weather factors

The spider population was positively significant correlation with morning relative humidity while, positively non-significant correlation with evening relative humidity. However, maximum temperature, minimum temperature, sunshine hours and total rainfall had non-significant negative influence on spider population.

Population of Ladybird beetle was negative and significant correlation with maximum temperature while, morning relative humidity had positively significant correlation with population of ladybird beetle. Minimum temperature, Sunshine hours and total rainfall had negatively correlated but there was no significant impact. Positive but non-significant association of evening relative humidity with population of lady bird beetle was observed.

Population of carabid larvae had non-significant correlation with weather parameters. Among the weather parameters under study, there was positively non-significant association between total rainfall, morning relative humidity and evening relative humidity and number of carabid larvae per plant. Maximum and minimum temperature and sunshine hours had non-significant negative influence on carabid larvae population.

Correlation coefficient between major pests of maize and their natural enemies

Positive correlation was found between fall armyworm and its natural enemy population *i.e.* carabid larvae.

1. Higher infestation of fall armyworm was observed during 30th SMW and 31th SMW while, less infestation was observed at crop harvesting stage. Maximum temperature, minimum temperature and sunshine hours had positive significant impact on the incidence of fall armyworm. The infestation of fall armyworm was positively correlated with population of its natural enemy *i.e.* carabid larvae

2. Incidence of natural enemies (spider, ladybird beetle and carabid larvae) was observed after the infestation of insect pests of maize. Morning relative humidity was positively significant impact on population of spiders and ladybird beetle while, maximum temperature was significant negative impact on population of ladybird beetle.
3. The present studies concluded that weather factor determines the seasonal activity and population build-up of insect pest in maize crop. The correlation studies clearly show the importance of weather parameters in predicting the major pest incidence and these studies will be definitely helpful to farmers and extension workers for developing efficient pest management strategies for sustainable maize production.

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Response of GA_3 and Humic Acid on Quality Parameters of Gladiolus

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Abstract: An experiment to study the response of GA_3 and humic acid on quality parameters of gladiolus was carried out during *Rabi* season of the year 2017-18 at Research Farm, Horticulture Section, College of Agriculture, Nagpur. A field experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 4 levels of GA_3 (G_0 -Control, G_1 –GA_3 100 ppm, G_2 –GA_3 200 ppm and G_3-GA_3 300 ppm) and factor B consist of 4 levels of humic acid (H_0 -Control, H_1 –1000 ppm Humic acid, H_2 –1500 ppm Humic acid and H_3 –2000 ppm Humic acid) with sixteen treatment combinations replicated thrice in a Factorial Randomized Block Design. The quality parameters *viz.*, length of spike, diameter of spike, length of rachis, florets spike^{-1}, vase life of flower, diameter of corm, weight of corms plant^{-1}, weight of cormels plant^{-1}were recorded maximum with an individual application of GA_3 200 ppm and humic acid 1000 ppm. The interaction effect of GA_3 and humic acid for all quality parameters were found non significant.

***Key words*:** Gladiolus,GA_3, humic acid and quality.

Introduction

Gladiolus (*Gladiolus grandiflorus* L.) is said to be the "queen of bulbous flowers" which has gained popularity in many parts of the world owing to its unsurpassed beauty. Its magnificent long lasting spike with variety of colour and form has made it attractive for use of herbaceous borders, rockeries, pots as well as cut flowers. However, the quality and production per unit area, particularly in Vidarbha region are still below the international standards.

Demand of gladiolus cut flower is increasing day by day but its commercial production is still at the initial stage in this country due to lack of scientific information regarding its cultivation technology such as size of planting material, depth of planting, planting time, fertilizer management, use of different growth regulators like GA_3, humic acid etc. which enhance the production and quality of gladiolus spikes as well as corms and cormels. Various research workers have reported that, the proper application of growth regulators like GA_3, humic acid helps to increase the yield of good quality spikes and corms in gladiolus. Hence, the present investigation was carried out to find suitable concentration of GA_3 and humic acid to obtain better quality of gladiolus.

Materials and Methods

The investigation was carried out at Research Farm, Horticulture Section, College of Agriculture, Nagpur during 2017 - 2018 under open field conditions with a field experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 4 levels of GA_3 (G_0 -Control, G_1 –GA_3 100 ppm, G_2 –GA_3 200 ppm and G_3-$GA_3$300 ppm) and factor B consist of 4 levels of humic acid (H_0 -Control, H_1 –Humic acid 1000 ppm, H_2–Humic acid 1500 ppm and H_3–Humic acid 2000 ppm) with sixteen treatment combinations replicated thrice in a Factorial Randomized Block Design. At the time of land preparation, well-rotten FYM @ 20 t ha^{-1} was mixed uniformly in the soil before last harrowing. The gladiolus corms of the variety "American Beauty" were obtained from Horticulture Section, College of Agriculture, Nagpur (M.S). The rested, cold stored, healthy and uniform sized gladiolus corms were used for planting .Then after giving treatment of fungicide for 15 minutes, corms were planted on raised beds at 5 cm depth. 15 days after planting foliar spray of GA_3 and humic acid was given as per the treatments. All the cultural operations *viz.*, weeding, staking, earthing up, pest control etc. were carried out as and when required. Irrigation was applied through drip irrigation system. Five plants were selected randomly from each plot for recording various quality parameters *viz.*, length of spike (cm), diameter of spike (cm), length of rachis (cm), florets spike^{-1}, vase life of flower (days), diameter of corm (cm), weight of corms plant^{-1} (g), weight of cormels plant^{-1}(g). Data was statistically analysed in FRBD (Panse and Sukhatme, 1967).

Results and Discussion

The data presented in table 1 revealed that, GA_3 and humic acid levels had significant effect on all quality parameters in gladiolus. However, the interaction effect of GA_3 and humic acid for all quality parameters were found non significant.

Effect of GA_3

Quality Parameters

GA_3 200 ppm recorded maximum length of spike (82.25 cm) which was found statistically at par with GA_3 100 ppm (79.82 cm). Whereas, control treatment recorded minimum length of spike (76.81 cm).This might be due to enhanced growth rate of vegetative plant parts due to enhanced physiological activities influenced by GA_3. It also increases photosynthetic and metabolic activities causing more transportation and utilization of photosynthetic products. This might have resulted into better length of spike. Similar results were recorded by Ravidas *et al.* (1992) in gladiolus, Rathod *et al.* (2011) in gladiolus and Sharifuzzaman *et al.* (2011) in chrysanthemum. GA_3 200 ppm recorded maximum diameter of spike (0.71cm) which was found statistically at par with GA3 100 ppm (0.69 cm). Whereas, the control treatment recorded minimum diameter of spike (0.63 cm). GA_3 might have increased diameter of spike due to production of better quality spikes in respect of diameter of spike. GA_3 200 ppm recorded maximum length of rachis (36.40 cm) which was found statistically at par with GA_3 100 ppm (35.30 cm) and GA_3 300 ppm (34.95 cm). Whereas, control treatment recorded minimum length of rachis (32.68 cm). GA_3 enhanced the cell elongation in the plants due to which the distance between two florets of gladiolus might have been increased and ultimately this might have elongated the rachis length. GA_3 200 ppm recorded maximum florets spike^{-1} (11.01) which was found statistically at par with GA_3 100 ppm (10.40). Whereas, control treatment recorded minimum florets spike^{-1} (8.68). Probably, this might be due to increase in length of spike and rachis due to promontory effect of gibberellin on cell division, cell elongation and vigour of plant which might have increased florets per spike. Similar results were recorded by Ravidas *et al.* (1992) in gladiolus and Rathod *et al.* (2011) in gladiolus. GA_3 200 ppm recorded maximum vase life of flower (10.26 days) which was followed by $GA_3$100 ppm (9.02 days) and GA_3 300 ppm (8.97 days). Whereas, control treatment recorded minimum vase life of flower (8.43 days). Probably, this might be due to an increase in length of spike and rachis due to promontory effect of gibberellin on cell division, cell elongation and vigour of plant which might have increased vase life of flower. Similar results were recorded by Ravidas *et al.* (1992) in gladiolus and Rathod*et al.* (2011) in gladiolus. GA_3 200 ppm recorded maximum diameter of corm (4.99 cm) which was found statistically at par with GA_3 100 ppm (3.64 cm). Whereas, control treatment recorded minimum diameter of corm (2.99 cm). Probably, This might be due to increased volume of intercellular spaces in mesocarpic cells due to enhanced physiological activities by GA_3 resulted in maximum diameter of corm. GA_3 200 ppm recorded maximum weight of corms plant^{-1} (50.05 g) which was found statistically at par with GA_3 100 ppm (47.84 g). Whereas, control treatment recorded minimum weight of corms plant^{-1} (40.16 g). GA_3 increased the plant height, number of leaves and leaf area that might have led to enhance rate of photosynthesis. As a result of this, availability of metabolites to the developing corms due to enhance physiological activities by GA_3 resulted in maximum diameter of corms and weight of corms plant^{-1} was also increased. GA_3 200 ppm recorded maximum weight of cormels plant^{-1} (7.19 g) which was followed GA_3 100 ppm (6.16 g) and GA_3 300 ppm (6.04 g). Whereas, control treatment recorded minimum weight of cormels plant^{-1} (5.18 g). Similar results were also recorded by Rathod *et al.* (2011) in gladiolus and Memon *et al.* (2013) in gladiolus.

Effect of Humic Acid

Quality Parameters

Humic acid 1000 ppm recorded maximum length of spike (81.88 cm) which was found statistically at par with humic acid 2000 ppm (79.66 cm). Whereas, control treatment recorded minimum length of spike (76.50 cm). Humic acid increased length of spike might be due to the role of humic acid in improving nutrients uptake and increase spike length. Humic acid 1000 ppm recorded maximum diameter of spike (0.70 cm) which was found statistically at par with humic acid 1500 ppm (0.69 cm). Whereas, the control treatment recorded minimum diameter of spike (0.64 cm). Humic acid increased diameter of spike might be due to the role of humic acid in improving nutrients uptake and increase diameter of spike. Humic acid 1000 ppm reported maximum length of rachis (36.39 cm) which was found statistically at par with humic acid 1500 ppm (35.16 cm) and humic acid 2000 ppm (34.74 cm). Whereas, control treatment reported minimum length of rachis (33.31 cm). Humic acid 1000 ppm recorded maximum floret spike^{-1} (10.50) which was found statistically at par with humic acid 1500 ppm (10.00) and humic acid 2000 ppm (9.98). Whereas, control treatment recorded minimum floret spike^{-1} (8.84). Similar results were reported by Ahmad *et al.* (2013) in gladiolus, Kaisam *et al.* (2014) in gladiolus and Khodakhah *et al.* (2014) in tuberose. Humic acid 1000 ppm recorded maximum vase life of flower (9.98 days) which was found statistically at par with humic acid 1500 ppm (9.63 days). H_0 and H_3 were found at par with each other. Whereas, the control treatment recorded minimum vase life of flower (8.07 days). Humic acid has auxin like activity enhanced nutrients uptake which may be responsible for the longer vase life of flower. Similar findings were found by Nikbakhat *et al.* (2008) in gerbera, Ahmad *et al.* (2013) in gladiolus, Kaisam *et al.* (2014) in gladiolus and Khodakhah *et al.* (2014) in tuberose. Humic acid 1000 ppm recorded maximum diameter of corm (3.98 cm) which was followed by humic acid 1500 ppm (3.59 cm) and humic acid 2000 ppm (3.40 cm). Whereas, control treatment recorded minimum diameter of corm (3.05 cm). Humic acid 1000 ppm recorded maximum weight of corms plant^{1} (47.66 g) which was found statistically at par with humic acid 1500 ppm (46.75 g) and humic acid 2000 ppm (45.90 g). Whereas, control treatment recorded minimum weight of corms plant^{-1} (43.09 g). Humic acid 1000 ppm recorded maximum weight of cormels plant^{-1} (7.03 g) which was found statistically at par with humic acid 1500 ppm (6.59 g). Whereas, control treatment recorded minimum weight of cormels plant^{-1} (5.17 g). Humic acid application greatly improved the quality parameters because it enhances the micro and macro nutrients uptake and reduce the water evaporation from soil. It also makes more mineral nutrients available to gladiolus plant or increased microbial population and biologically active metabolites by such plant growth regulator. Similar results were found by Ahmad *et al.* (2013) in gladiolus, Kaisam *et al.* (2014) in gladiolus and Khodakhah *et al.*(2014) in tuberose.

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Survey for Occurrence of Rust and Other Diseases of Soybean in Yavatmal District

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Abstract: The survey was undertaken to know the prevalence of rust and other major diseases of soybean on June/July sown soybean crop from seedling to crop maturity stage in Yavatmal district during 2013 to 2017. Incidence of root diseases *i.e.* root rot /collar rot, *Myrothecium* leaf spot, bacterial pustule and pod blight were recorded from most of the growing areas. Incidence of mosaic was observed during, 2015. *Sclerotium rolfsii, Myrothecium roridum, Xanthomonas axoenopodis* Pv *glycine, Colletotrichum truncatum* and *Rhizoctonia bataticola* were isolated from roots/collar region, leaves, pods and seeds. Incidence of root/collar rot was 0.00 to 10.00 %. Among foliar diseases, infection level of *Myrothecium* leaf spot was 11.48% to 15.93% and per-cent disease intensityof bacterial pustule was 0.00 to 24.07%. Bacterial pustule was highest at pod development to crop maturity stage. Mosaic was maximum *i.e.* 14.01% in Darwha tahsil. However, rust was not observed throught the survey.

Keywords: *Soybean, Survey, Root rot and Foliar diseases*

Introduction

Soybean (*Glycine max* (L.) Merril, is a wonderful legume, an important oilseed and pulse crop in India. In recent year soybean proved to be a boom in changing the economy of cultivators. Area under soybean is now fast increasing in Vidharbha region of Maharashtra. During 2006-07, the area was 15.71 lakh hectare in Vidharbha (Anonymous, 2008). In Vidharbha region of Maharashtra soybean is cultivated in Akola, Amravati, Buldhana, Chadrapur, Nagpur, Wardha and Yavatmal district. In Yavatmal district, the area was 2.68 lakh hectare in, 2006-07 (Anonymous, 2008). In the recent year the most commonly grown varieties of soybean in Yavatmal district of Vidharbha are JS 335, JS 9305, TAMS 98-21, NRC 37, MAUS 71, MAUS 158, MAUS 81 and MAUS 162. Seedling diseases viz, root and stem diseases, foliar diseases were severe in Vidharbha region. Seed borne pathogens are responsible for causing seed rot, seedling blight and foliar diseases in soybean (Agrawal and Joshi, 1972). Manglekar and Raut (1997), have reported the prevalence of bacterial pustule caused by *Xanthomonas campestries* pv *glycine*, *Cercospora* leaf spot or purple blotch (*Cercospora kikuchi*), root/stem rot cause by *Rhizoctonia bataticola*, seedling blight (*Sclerotium rolfsii*) and unidentified virus. Among the diseases, bacterial pustule and charcoal rot or *Macrophomina* blight, caused due to *Macrophomina phaseolina*, while *Rhizoctonia* caused root/stem rot are the most destructive diseases in Vidharbha, can cause to the extent of 30 per cent grain yield and 18 per cent plant weight losses. Khodke *et.al.*(2000) reported incidence of rust caused by *Phakopsora pachyrhizi* from Yavatmal district on cv JS 335 and PKV-1.Hegde et.al.(2003) reported rust of soybean appeared in very severe form during *kharif* 1999 and 2000 in soybean growing areas of Karnataka. The severity was more *i.e.*27.93 per cent during 2000. Therefore to collect the information on soybean root/stem and foliar diseases in Yavatmal district, the present studies were undertaken.

Materal and Methods

During *Kharif* season 2013 to 2017, survey of July sown crop of soybean was undertaken in 3 tahasils of Yavatmal district. In soybean field, 1×1m area at two location was marked for recording disease incidence/ intensity. Regarding root diseases, in marked area total number of plants and infected plants were counted and per cent incidence was worked out. For foliar diseases, intensity of diseases was worked as per the scale 1-9, given by XVII Annual soybean work shop held at Indore (1986-87). As regard to pod blight, 10 plants were selected randomly from the marked area, total number of pods and infected pods were counted and per cent incidence was worked out. Samples of diseased plant were collected and brought into laboratory for confirmation of organisms involved.

Results and Discussion

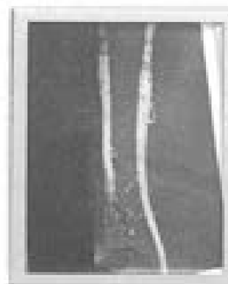
Table 1. Occurrence of Soybean diseases in Yavatmal district during *kharif* 2013 to 2017

Year	Name of disease and their intensity (%)					
Kharif of	Collar/root Rot	*Myrot hecium* leaf spot	Bacterial pustule	Rust	Virus symptom	Pod blight
2013	6.67-10.00	1148-13.22	11.85-14.7	-	-	00.00-3.98
2014	0.5-8.00	11.85-14.44	0.00-12.96	-	-	0.0-2.00
2015	1.35-2.22	12.22-13.52	11.85-24.07	-	0.00-14.01	2.22-3.67
2016	1.11-3.09	12.22-3.33	11.85-16.48	-	-	0.00-3.49
2017	1.0-6.25	12.98-15-93	12.59-15.19	-	-	0.00-10.70

The data indicated that *Myrotheciu* leaf spot, bacterial pustule and root rot/collar rot were commonly observed in the Yavatmal district (Tab.1& Fig. A-D). Incidence level of collar/root rot was 0.00 to 10.00 per cent. The infection of root/collar rot was noticed at seedling and pod development stage on cv JS 9305 and JS 335. Borkar (1992) reported that root rot and collar rot cause wilting particularly at young stage of soybean. Infection of root rot and collar rot was reported in Vidharbha by Manglekar and Raut, 1997; Khodke and Wankhade, 2010. Among the foliar diseases, leaf spot and bacterial pustule were commonly observed in Yavatmal district (Tab.1& Fig. C).The intensity of *Myrothecium* leaf spot and bacterial pustules were 11.48 to 15.93 per cent and 0.00 -24.07 per cent, respectively. Intensity of bacterial pustule was high i.e.24.07 per cent at pod development stage in tahsil Digras on cv JS 335.Prevalence of bacterial pustule in Vidharbha have been reported by Gaikwad *et al*.,1995; Manglekar and Raut(1997) ; Khodke and Wankhede(2010). These results are on the line of present observations. Viral infection was observed on cv JS 335 during *Kharif* 2015 in tah. Digras and Darvha. Incidence of viral infection was 12.22 per cent and 14.01 percent, respectively. Soybean is infected by virus like yellow mosaic (Suteri and Srivastava, 1979). Manglekar and Raut, (1997) reported unidentified virus disease in Akola district on MACS 13 at pod development stage. However, rust was not observed during the survey. As regards to pod blight infection, severe incidence *i.e.* 10.00 per cent was noticed in the year 2017, (Tab.1& Fig. A-D). The higher disease incidence may be attributed to continuous rainfall during 39thMW-43 MW *i.e.* at pod development to crop maturity stage of the crop. *Sclerotium rolfsii*, *Myrothecium roridum*, *Xanthomonas axenopodis* pv glycine, Colletotrihum *truncatum* and *Rhizoctonia bataticola* were isolated from root /collar region, leaves, pods and seeds.

A. Infection of *Rhizoctonia bataticola* on stem and pods

B. Infection of *Rhizoctonia bataticola* on stem and root



Collar rot of soybean caused by *Sclerotium rolfsii* White growth of *Sclerotium rolfsii*

C. Bacterial pustule on soybean leaves

C. Infection of virus on soybean leaves

Conclusion

Root/collar rot, bacterial pustule was occurred in Yavatmal district. The findings of the present investigation could be attributed to seed application of treatment with suitable seed dressing fungicides and/or precautionary measures of label claimed chemical fungicides and cultivation of resistant genotypes.

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Review : Effect of Sound Against Seed Borne Microflora of Soybean *in-vitro*

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Abstract: Music plays an important role in the growth and development of plants. The audible sound that human can hear falls into frequencies ranging from 20 hz- 20, 000 hz (hertz). Exposure of seedling and mature plant to green music, classical music and nature sounds, gayatri mantra, pirith, elevates the levels of polyamines and increased the uptake of oxygen. There is a positive impact on overall plants like wheat, spinach, horse gram, soya and paddy. Musical vibrations have stimulated seed germination of certain plants. The frequencies in these vibrations facilitate the physiological processes like nutrient absorption, photosynthesis, protein synthesis and an overall development of healthier plants with better yield.

Audible sound (20–20000Hz) widely exists in natural world. However, the interaction between audible sound and the growth of plants is usually neglected in biophysics research. Not much effort has been put forth in studying the relation of plant and audible sound. In this work, the effect of sound on germination and growth of soybean (*Glycine max*) will be studied under laboratory condition.

Audible sound ranging, Sound pressure level (100dB), Exposure period 15, 30 and 60 min., Distance (20 cm and 40 cm), and Frequency (1 kHz)were used to stimulate soybean. The growth of soybean was evaluated in terms of mean germination time, total length, and total fresh weight. Experimental results indicated that the sound wave can reduce the germination period of soybean and the soybean under treatments of sound with intensity around 100dB and frequency around 1 kHz and significant increase in growth and reduce the attack of seed borne micro-organisms and we will get disease free plant. Audible sound treatment can promote the growth of soybean differently for distinct frequency and intensity. The study provides us with a way to understand the effects of sound field on plant growth and a new way to improve the production of soybean.

Keywords: soybean, seed germination, music, frequency.

Introduction

The use of sound and music to improve the health of living organisms is not a novel idea. Indeed, the beneficial and harmful effects of sound in terms of music were recognized by the ancient Greeks and Romans (Rooke, 1985). Music, which is made up of sound waves with different frequencies and intensities (Telewski, 2006), has been used for the treatment of illnesses, including neuropathy and depression (Wicke, 2002). Dr. TC Singh first studied the effects of music on plants in the 1950s (Tompkins and Bird, 1989). In 1973, D Retallack published a book titled, "The Sound of Music and Plant", which described experiments involving plants and music. In these experiments she played sounds and particular styles of music to plants and found that the best growth results were obtained when classical music was played. Moreover, stimuli such as sound fields, supersonic sound, electromagnetic fields, micro gravity, and mechanical vibrations impacted plants (Bush, 1995; Fraze, 1996).

Sir Jagdish Chandra Bose was one of the pioneers to study the behaviour of plants in responses to various stimuli. Living organism has the ability to sense and respond to different physical stimuli, light, temperature and a variety of chemical signals, that are common environmental physical stimuli detected by biological organisms. External induced pressure gradients are in aquatic system. Musicial sound has a significant effect on number of seeds sprouted compared to noise and untreated control and sound vibrations directly affected living biological process. Seed are sometimes treated with ultrasound to help the germination process.

Seeds have been irradiated in order to analyze the effects of radiations. The radio sensitivities of different plants has shown considerable variations. Sound wave can accelerate growth of plants and the stimulation of sound wave has an obvious effect on the growth and development of plants. Music, noise and healing energy has certain effect on germination of seeds. Musical sound shows better germination percentage as compared to untreated control. Sound vibrations directly affect the living systems and also the effects caused by various applied energetic conditions can be detected by seed germination bioassay. There are certain melodies that help the plants to grow. The effect of sound has been studied on the isothermal germination of seeds.

In consideration with the hypothesis, plants do not hear the music, they feel it. Sound is nothing but a wave traveling through a medium (air or water). The particles in the medium are at a mean to vibrate due to these waves. For an instance, turning on the radio, the sound waves in the medium, i.e., air creates vibrations, which causes your ear drum to vibrate. This energy is converted in to electrical energy, which helps understand brain that it's a musical sound. Similarly, is the phenomenon in which plants picks up the sound waves through protoplasm and helps increase the proficiency of the plant growth.

Overall, little research has been conducted in this field due to the lack of precise instrumentation to measure the response of plants to sound as well as a lack of confirmed scientific information in this area of study. Therefore, we are conducting research to determine the relationship between the exposure of plants to sound and subsequent plant growth. Growth response depends on the frequency and intensity of sound (Liu et al., 2001). It is known that different frequencies and intensities of sound impact different plants; however, further studies are needed to clarify these variations. Here, we have summarized the impact of sound waves and music on plant response in terms of growth and development.

Methodology

The present investigation entitled "Effect of sound against seed borne microflora of soybean in vitro" The detailes of experimental material used and method will be evaluated as follows.

1. Seeds of soybean crop procured from the department of seed technology Post Graduate Institute MPKV, Rahuri..
2. The seeds treated with the help of sound stimulation generator/ laptop. The following setting done for the actual treatment.
   a. Sound pressure level (100dB)
   b. Exposure period 15, 30 and 60 min.
   c. Distance (20 cm and 40 cm)
   d. Frequency (1 kHz)
4. With the help of filler germination trials standardization all parameters are done.
5. Once the treatment finalized empact of seed microflora of soybean seed is observed.

Conclusion

The present investigation entitled "Effect of sound against seed borne microflora of soybean *in-vitro*." was undertaken , it is concluded that music has a positive effect on the seed germination due to enhanced metabolic rate of growth and development. Various forms of music and their different frequencies have a enhancing role in seed growth parameters. Therefore, a immense scope is present in exploiting music as a tool for breaking seed dormancy and enhanced the yield.

Due to the experimental results it is concluded that sound waves reduce period of germination of soybean under the treatment of sound may significant increase in growth and reduce the attack of seed borne microorganism.

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Studies on Feeding of Urea Ammoniated Soybean Straw and Effect on Productive Performance of Lactating Cows

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Abstract: Enrichment of soybean straw with urea increases the palatability and acceptability of in cows, Enrichment with 2% urea treatment can increase CP content by 42% (9.67%) over untreated SBS. Enrichment with urea increases the palatability and acceptability of SBS in cows, there by more consumption of straw by 42% in reference to untreated straw. Urea treated straw based ration contained 6.28% DCP and 55.12% TDN against a content of 5.68 and 53.05 per cent in untreated SBS diet, respectively. Lactating cows reared on enriched SBS ration produced 26 % more milk in comparison to feeding of untreated SBS ration. Feeding of urea treated diet to cows is beneficial to improve fat, protein, SNF and TS content of milk. The cost of feed/kg milk yield can be reduced by 40% on urea enriched SBS ration in comparison to cost of feeding un treated SBS ration. The cows need 39% less concentrates to produce 5 kg milk/day on feeding 2% urea treated SBS diet in reference to feeding of untreated SBS diet.

Key Words: Jowar straw, Soybean straw (SBS), 2% urea treated SBS, Proximate analysis, Nutritive value, Dry matter Intake (DMI), Milk yield, 4% Fat Corrected Milk (FCM), Milk quality, Cost of production.

Introduction

During couple of years, a significant change in cropping pattern has been noticed where the farmers have concentrated on the cultivation of crops like soybean having low cost of production and remunerative selling price in the market, this situation reflected on the acreage of traditional crop like sorghum, bajra and maize as well as to some extent on cultivation of pulses and wheat crops, creating the shortage of established conventional straws to animal feeding. In addition to that soybean straw is a leguminous crop and its straw is superior in Nitrogen content as compared to cereal crop straws like sorghum straw, wheat straw and rice straw. However high lignin content (16.18%) of SBS makes the straw most lignified coarse and fibrous in nature. For sustaining profitability of a livestock enterprise balanced and economic feeding is essential. Inadequate supply of quality fodder with better digestibility has been recognized as one of the reason for poor livestock production in India (Annual report of GCMMF, 2015-16, Kumar, et al.,(2016). Soybean (Glycine max, L.) is a major crop grown for its protein and oil rich seeds but it also makes valuable feed and fodder ((Heuze, *et al.*, 2016), but soybean straws are coarse and fibrous which cause digestibility (Blount et al, 2013).Urea treatment may be the most suitable method for small scale farmers to improve the quality of straws (Hanafi *et al.*, 2012, Gunun, *et al.*, 2013). On the basis of these facts an effort was made to find out the utility of same in the diet of lactating cows and its effect on productivity.

Material and Methods

Fifteen mid lactation stage cows were selected and randomly divided into three groups on the basis of nearness in their average milk production and body weight. Further, each group was allocated randomly to treatments, namely, Untreated Jowar straw ad lib. + Concentrate mixture 1kg for maintenance and 40% for milk production (T_1), Untreated Soybean straw ad lib. + Concentrate mixture 1kg for maintenance and 20% for milk production (T_2) and 2% Urea ammoniated Soybean straw ad lib. + 1kg Concentrate mixture for maintenance (T_3). Beside this, 5 kg green fodder (Hybrid Napier- Yashwant) fed to all cows and Concentrate (Sugras a product of MAIDC) was fed as per treatment. The feed stuffs i.e. Jowar straw, untreated/ treated soybean straw, Hybrid Napier and concentrate (Sugras) were analyzed for proximate analysis as per the standard procedures recommended by the Indian Standard Institute (BIS- 7874, Part –I, 1975) and digestibility, DCP and TDN were calculated by standard formulas referred by Jagdish Prasad and Neeraj (2008). The feed conversion efficiency and protein efficiency were worked out by using the formulae suggested by Jumah et al. (1965) and Nawab Singh et al. (1987). The feed intake was quantitatively measure to assess the dry matter intake. Milk yield was recorded both in the morning and evening for whole experimental period. 4% FCM was calculated by using formula (Sastri and Thomas, 1976), Specific gravity, Fat, Protein, Solids-not-fat, Total solid content of milk were determined by using Standard methods as prescribed in AOAC, (1991) and IS: 1224 (Part I),(1977). Economics of feeding was judged on the basis of daily cost of feeding and feed cost per lit milk production. The cost of feeding was calculated by considering the rates of roughages approved by the university and purchase rate of concentrate mixture. The processing charges were work out on the basis of labour requirement, electricity, consumption and other miscellaneous charges. The experimental data were analyzed statistically by using the procedure as given by Amble (1975).

Result and Discussion

Average proximate composition (per cent) of different feed stuffs was determined on dry matter basis and presented in Table 1. Nutritive values and feed conversion efficiencies of different feeding groups were worked out from the data of present investigation and presented in Table 2. This indicates that there is positive impact on quality of soybean straw as livestock feed due to urea treatment and recorded positive effect on CP and ash content while decreased crude fiber. DCP, TDN, Feed Conversion Efficiency, Gross and Net Protein Efficiency was also improved significantly, which proves improvement in the quality of soybean straw. The actual intakes of feeds are important for expressing productivity, considering same DMI of cows under different treatments over the experimental period were worked out from the total intake of different feeds and overall averages DMI kg/day/cow under different feeding treatments are compared with standard norms of 2.5 kg DM/100kg body weight (Jagdish Prasad and Neeraj, 2008) and presented in Table 3.

Table 1: Average proximate composition of different feed stuffs (% DM basis)

Name of Feed stuff	DM	Composition of nutrients					Lignin
		CP	EE	NFE	CF	Ash	
Jowar straw(T_1)	90.63	2.36	2.89	48.56	37.67	8.52	4.36
Un-treated SBS(T_2)	90.36	6.80	1.69	40.31	39.24	11.96	16.32
2.0% urea treated SBS (T_4)	89.54	9.67	1.72	39.23	36.82	12.56	13.17

Table 2: Nutritive values and feed conversion efficiencies of different treatments.

Treatment	Nutritive value %				Feed conversion efficiency (%)	Gross protein efficiency (%)	Net protein efficiency (%)
	CP	DCP	TDN	NR			
T_1	7.84	4.72a	64.91a	1:10.63	46.67	32.88	57.65
T_2	10.01	5.68b	53.05b	1: 8.34	55.84	34.23	59.86
T_3	10.73	6.28c	57.11c	1: 7.78	61.04	35.97	60.70

Table 3. Average DMI (kg/day/cows) in comparison to feeding standards

Treatment	BW (kg)	DMI (kg)	DM requirement (kg) (2.5kg%BW)	Per cent (excess/ deficit) intake
T_1	291.29	8.88	7.28	+21.97
T_2	296.38	7.48	7.41	+0.94
T_3	299.42	8.60	7.49	+14.82

DMI in cows of all the treatments was sufficient to meet out nutritional norms. The cows reared on Jowar straw and urea treated SBS ration received more DM by 21.97 and 14.82% in comparison to recommended levels. Similar results also noted by Mudgal (2010) who observed no negative effect on the dry matter intake of SBS. Nguyen et al. (2012) reported that Urea treatments as nitrogen source improves the intake, digestibility and utilization of low-quality roughages.

Productive Performance of cows

Average daily milk yield and milk quality is judged on the basis of different chemical properties, particularly Fat and SNF contents. Considering these aspects, the data obtained in this regard are presented in Table 4. Data presented in Table 4, indicates that the weekly total milk production (kg/cow) of the cows differ significantly between the feeding treatments. The cows from 2% Urea treated (T_3) group produced 24 to 26% more milk and beneficial to increase the milk production in cows. Soloman (2000) reported increase in milk production of cows by 7 to 10% with feeding of Soybean by products. Arriaga et al. (2010) observed significant differences in milk yield as a result of different intake of Nitrogen, supporting the trends of present trends. Presently milk procurement prices are dependent on fat content of the milk. The milk having fat content more than legal standards (3.5%) received additional bonus price. Considering this, 4% Fat Corrected Milk (FCM) was worked out and presented in Table 2 and the trend indicates that the cows from T_3 group produce approximately 29.71 and 25% more FCM over that of T_1 and T_2 group cows respectively. The trend of results agrees with past work reported by Khalid Hanafi et al. (2012). A reference to Table 4, indicates that natural acidity in terms of % lactic acid and specific gravity did not change significantly by the feeding treatments. This means that feeding of SBS to lactating cows produced the milk of normal quality and had no adverse effect on the salt balance of milk like citrate, phosphate and chlorides and concentration of milk solids in milk.

Table 4: Average yield and quality of milk over experimental period under different treatments.

Sr. No.	Milk quality parameters	Treatments			F Test	SE M ±	C.D.	CV
		T_1	T_2	T_3				
1	Daily Milk yield kg/cow Mean	4.15	4.18	5.25	Sig	0.1654	0.4586	5.18
2	Acidity(%LA)	0.126	0.127	0.126	NS	0.00047	--	5.6173
3	Spp. gravity	1.0285	1.0290	1.0292	NS	0.000164	--	0.1470
4	Fat (%)	4.40	4.42	4.41	NS	0.0156	0.0433	3.1660
5	Protein	3.32	3.48	3.70	Sig.	0.0077	0.0215	2.0034
6	Solids Not Fat	8.70	8.98	9.21	Sig.	0.0047	0.0129	1.4997
7	Total Solids	13.10	13.40	13.62	Sig.	0.0036	0.0100	0.9330
8	Feed cost Rs. /kg Milk Prod.	12.00	8.91	6.32	Sig.	0.5789	1.3673	1.6639

- Sig.- Significant, NS- Non significant., CD at $P<0.05$.

The fat content of milk was affected significantly by the feeding treatments. Significantly highest fat content in milk (4.69%) was noticed when the cows were reared on T_3 diet, followed by T_2 and T_1 treatments. Feeding of either untreated or urea treated SBS was increasing milk proteins by 4.82 and 11.45% over that of conventional Jowar straw and concentrates feeding to the cows. Mewara et al.(2008),and Kamal et al.(2012) reported similar results which supports the present results. Inclusion of urea treated SBS in the ration of lactating animals did not hamper the SNF content in milk. Similarly milk SNF reported by Gopalkrishana (2012) are supportive to present results. Significantly highest TS content was noticed in milk produced by the cows in T_3 group, followed by T_2 and T_1 groups. This trend appears obvious as fat and SNF content of milk in T_3 group were more and these are the contributing constituents for emerging out TS content of milk.

The cost of feed/kg milk yield can be reduced by 40% on urea enriched SBS ration in comparison to cost of feeding un treated SBS ration. The cows need 39% less concentrates to produce 5 kg milk/day on feeding 2% urea treated SBS diet in reference to feeding of untreated SBS diet.

Conclusion

On the basis of data obtained in the present investigations it is concluded that, Leguminous SBS emerged out as alternative non conventional roughage to replace cereal straws. SBS possesses higher feeding value, containing 6.8% CP, of which 59% is digestible. Enrichment with 2% urea treatment can increase CP content by 42% (9.67%) over untreated SBS. Enrichment with urea increases the palatability and acceptability of SBS in cows, there by more consumption of straw by 42% in reference to untreated straw. Urea treated straw based ration contained 6.28% DCP and 55.12% TDN against a content of 5.68 and 53.05 per cent in untreated SBS diet, respectively. Lactating cows reared on enriched SBS ration produced 26 % more milk in comparison to feeding of untreated SBS ration. Feeding of urea treated diet to cows is beneficial to improve fat, protein, SNF and TS content of milk. Approximately 61% of the enriched SBS consumption is converted to milk production by the cows. The cost of feed/kg milk yield can be reduced by 40% on urea enriched SBS ration in comparison to cost of feeding un treated SBS ration.

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Effect of Application of FYM and Chemical Fertilizers on Yield and Proximate Analysis of Lucern Green Fodder

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Abstract: The present investigation entitled "Effect of application of FYM and chemical fertilizers on yield and proximate analysis of lucern green fodder" was conducted at Department of Animal Husbandry and Dairy Science, Post Graduate Institute, Dr PDKV, Akola for period 90 Days. Three treatments were studied namely T_1 – Nutrient management through organic manure and bio-pesticide for lucern fodder, T_2 –Nutrient management through fertilizer and IPM for xv lucern fodder and T_3 – Nutrient management through fertilizer and pesticide for lucern fodder. After 90 days of experiment fodder grown were analyzed for yield and proximate composition of lucern green fodder. The mean yield of maize green fodder under treatment T_1, T_2 and T_3 was 3.18, 3.77 and 3.74 ton respectively and yield results were significant at 5 % level of significance. The results revealed that Dry Matter value was 19.20, 19.28, 19.21 percent, Crude Protein value was 18.71, 18.70, 18.72 percent , Crude fiber value was 28.42, 28.44, 28.59, Ether Extract value was 4.37,4.40, 4.57 percent, Total Ash value was 7.22, 7.22, 7.17 percent, Nitrogen Free Extract value was 41.08, 40.92, 40.71 percent respectively for T_1, T_2 and T_3 . For its proximate analysis the results were non- significant at 5 % level of significance.

Keywords : FYM, Chemical fertilizer, Lucern green fodder, Yield, Chemical composition

Introduction

India is blessed with diversified type of livestock and it is one of the largest in the world. The green fodder production in the country is not sufficient to meet the requirements of the growing livestock population and also the forages offered to animal are mostly of poor quality. At present, the country faces a net deficit of 10.95% dry crop residues, 35.6 % green fodder and 44% concentrate feed ingredients. The animals are largely fed on low quality fodders such as different crop residues, paddy and wheat straw, weeds and wild grasses from wastelands and forest. Such low quality feeding material leads to low milk productivity per animal. This situation needs to be addressed through alternative sources of green fodder which could provide good quality green fodder so that the milk productivity as well as animal health may not jeopardized. Cereal-legume intercropping has been recognized as a beneficial crop production system for higher fodder production per unit area per unit time. (Vision document-ICAR-IGFRI, Jhansi, 2015). Lucern is a highly esteemed fodder, commonly grown in the winter season. The fodder is excellent, highly nutritive and sustainable either in green or dry condition and highly responsive to nitrogen fertilizer application. Excessive and imbalanced use of chemical fertilizers has adversely affected the soil causing a decrease in organic carbon reduction by microbial flora of the soil, and increasing use of nitrogen fertilizer is contaminating water bodies thus affecting fish fauna and causing health hazards to human beings and animals. (Begum, 2003). organic manures have a significant role to play in nutrient supply. In addition to improving soil physico-chemical properties, the supplementary and complementary use of organic manure also improves the efficiency of mineral fertilizer use.

Material and Methods

The present investigation was carried out in the Department of Animal Husbandry and Dairy Science, Dr. PDKV Akola, during the year 2019-20 for a period of 90 days. Treatment Details: T_1 – Nutrient management through organic manure and bio-pesticide for lucern fodder, T_2 –Nutrient management through fertilizer and IPM for xv lucern fodder and T_3 – Nutrient management through fertilizer and pesticide for lucern fodder. The field with well fertile and good water holding capacity soil was selected followed by tillage operation i.e. ploughing operation was carried on before research work start. At that time applied FYM (Farm Yard Manure) @ 5 tonnes as per the treatment of research plot .Then other tillage operation was carried like harrowing on the ploughed plot. Anand -2 variety of lucerne was selected for sowing. The sowing performed on 1 hectare field area required 10 kg seed of lucern fodder. Dose of fertilizer for particular treatment i.e. 20:80:40 kg NPK per hectare was applied. The pest attack was observed on Lucerne fodder after 40 days of sowing .most of the seedling leaves was damaged by grasshopper the pest of. Therefore, spray the of metarhizum @ 4 ml per 10 litre of water on treatment plot T_1.Then, spray the neem Seed Extract @ 4 ml per 10 litre of water, clean the weed and burned the plant debris on treatment plot T_2 Also spray the coragen @ 4 ml per 10 4litre of water on treatment plot T_3. The yield of fodder obtained from cutting of fodder crop weight in ton. The sample was taken at 50 % flowering of green fodder. The green fodder seedling cut down and collected the sample of five seedlings of each treatment for chemical analysis. Chemical Analysis of collected fodder sample in the laboratory Dry matter, crude protein, crude fibre, ether extract, total ash and nitrogen free extract for the samples were determined as per procedure given for proximate principles analysis according to AOAC (1990) and BIS, IS: 7874 (part-I) -1975. The data obtained was subjected to the statistical analysis by following the Randomized Block Design (RBD) for testing their difference as per procedure described by Amble (1975).

Results and Discussion

Yield of green fodder: The green fodder yields obtained from different treatment were analyzed and presented in Table 1.

Table 1 Effect of application Of FYM and chemical fertilizers on yield of lucern fodder

Treatments	Replications (Mean value of three cuttings in Ton)				Mean
	R-I	R-II	R-III	R-IV	
T_1	3.14	3.22	3.17	3.21	3.18
T_2	3.54	3.81	3.98	3.78	3.77
T_3	3.85	3.66	3.59	3.88	3.74
F Test	Sig				
SE(m) ±	0.078				
CD at 5 %	0.274				

The results revealed that yield of Lucerne fodder at various treatments were 3.18, 3.77 and 3.74 ton in treatment (T_2), (T_4) and (T_6) respectively and results was found significant at 5% level of significance. The mean yield of green Lucerne fodder treatment (T_2) was highest (3.77 tonne) as compare to other treatment. These results recorded in the present investigation are also supported and in agreement with results recorded by Pathan and Kamble (2014) observed that 4639.95 kg and 4782.09 kg/ha yield of green Lucerne by application of FYM and chemical fertilizer respectively.

Proximate composition of green fodder: The green fodder sample was taken from different treatment were analysed for their chemical composition and presented in Table 2

Table 2 Effect of application of FYM and chemical fertilizer on proximate analysis of lucern green fodder

Treatments	Chemical composition (% DM basis)					
	DM	CP	CF	EE	NFE	Total Ash
T_1	19.20	18.81	28.42	4.37	41.08	7.22
T_2	19.28	18.70	28.44	4.40	40.92	7.22
T_3	19.21	18.72	28.59	4.57	40.71	7.17
F Test	NS	NS	NS	NS	NS	NS
SE(m) ±	0.035	0.109	0.148	0.118	0.176	0.025

Dry Matter: The result recorded that dry matter content of Lucerne fodder at various treatments were 19.20, 19.28 and 19.21 percent in treatment (T_1), (T_2) and (T_3) respectively and results was found non- significant at 5% level of significance the dry matter content of Lucerne fodder These results recorded in the present investigation are also in agreement with results recorded by Madhekar and Mungikar (2009) observed that dry matter content of fertilizer applied Lucerne fodder was between 18.18- 23.18 percent. Babu et al. (2014) recorded that dry matter content in Lucerne fodder by application of FYM and fertilizer was between 15.98-21.94 percent.

Crude protein: It was also observed that crude protein content of Lucerne fodder at various treatments were 18.81, 18.70 and 18.72 percent in treatment (T_1), (T_2) and (T_3) respectively and results was found non significant at 5% level of significance. These results are supported and in agreement with results recorded by Madhekar and Mungikar (2009) observed that crude protein content of fertilizer applied Lucerne fodder was between 17.18- 22.50 percent. Babu et al. (2014) studied that crude protein content by application of FYM and fertilizer on Lucerne fodder was between percent 20.50- 23.50 percent.

Crude fibre: It was observed that crude fibre content of Lucerne fodder at various treatments were 28.42, 28.44 and 28.59 percent in treatment (T_1), (T_2) and (T_3) respectively and results was found non- significant at 5% level of significance. Crude fibre content of Lucerne fodder T_3 treatment was numerically highest (28.59 %) among all the treatments. These results recorded in the present investigation are also in agreement with results recorded by Madhekar and Mungikar (2009) estimated that crude fibre content of fertilizer applied Lucerne fodder was between 23.8-33.6 percent. Babu et al. (2014) reported that crude fibre content by application of FYM and fertilizer on Lucerne fodder was between 19.20 20.0 percent.

Ether Extract: The result recorded that ether extract content of Lucerne fodder at various treatments were 4.37, 4.40 and 4.57 percent in treatment (T_1), (T_2) and (T_3) respectively and results was found non- significant at 5% level of significance. These results recorded in the present investigation are also supported with results recorded by Babu et al. (2014) recorded that ether extract content by application of FYM and fertilizer on Lucerne fodder was 4.90 percent.

Nitrogen free extract: It was observed that nitrogen free extract content of Lucerne fodder at various treatments were 41.08, 40.92 and 40.71 percent in treatment (T_1), (T_2) and (T_3) respectively and results was found non significant at 5% level of significance. This results are also supported by the results of Lunagariya and Pande (2016) who estimated the nitrogen free extract in lucerne straw was between 40.75- 44.90 percent.

Ash: The ash content of Lucerne fodder at various treatments were 7.22, 7.22 and 7.17 percent in treatment (T_1), (T_2) and (T_3) respectively and results was found non- significant at 5% level of significance. These results recorded in the present investigation are in agreement with results recorded by Ayub et al. (2002) estimated that ash content of fertilizer applied maize fodder was between 8.17-10.17 percent. Madhekar and Mungikar (2009) resulted that total ash content of fertilizer applied Lucerne fodder was between 4.70-7.85 percent.

Conclusion

From the results obtained in present study it is concluded that the effect of FYM and chemical fertilizer application on yield and proximate composition of lucern green fodder was found statistically Significant and non significant, respectively.

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Effect of Feeding Urea Ammoniated Soybean Straw on Plane and Digestibility of different Nutrients in Calves

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Astract: The present investigation entitled "Effect of Feeding urea ammoniated soybean straw on plane and digestibility of nutrients in Calves" was carried out at Instructional farm, Department of Animal Husbandry and Dairy Science, Dr. P.D.K.V., Akola (MS). Twenty descript calves ranging from 60 to 90 kg body weight and 7 to 11 months age was selected and divided into four groups. The randomly divided groups were subjected to four different feeding treatments as untreated soybean straw (T_1), 1.0 % urea treated Soybean straw (T_2), 1.5 % urea treated Soybean straw (T_3) and 2.0 % urea treated Soybean straw (T_4). Daily DM intake was maintained as per standard. All the parameters regarding the body growth were carried out at weekly during experimental period. It was observed that intake of DM, DCP and TDN was higher than recommended levels in all the calves. However, the rate of consumption was more on 1.0 % urea treated SBS diet over the rest of the treatments. Digestibility of DM, CP, CF and NFE were significantly higher in T_2 diet over rest of the diet, resulting higher daily intake of different nutrients in calves. The calves fed with 1.0 % urea enriched SBS (T_2) diet received significantly more quantity of CP and CF by 16.77 and 11.68 %, respectively against the intake under USBS diet. All the calves except T_4 group received sufficient quantity of DM, DCP and TDN over their requirements. Whereas, the calves from T_4 group received marginally less (3.14%) TDN in reference to their recommended requirements. Feeding value in terms of DCP and TDN increases with the increase level of urea treatment of SBS from 1.0 to 2.0 per cent.

Keywords: CP, TDN, NFE, DCP, DM, Digestibility, Soybean straw (SBS), Urea

Introduction

Today India ranks first in milk production, accounting for 18.5 % of world production, achieving an annual output of 186.7 million tones during 2018-19 as compared to milk production during 2017-18 recording a growth of 8.26 %. The per capita availability of milk in India has increased from 176 grams per day in 1990-91 to 394 grams per day by 2018-19 (Anonymous 2019). Fortunately, country is blessed with huge bovine population, possessing 192 million cattle and 110 million buffaloes which accounts to 19 and 51 per cent of the world population. Beside this, 74 million sheep's and 149 million goats are also contributing their share in milk production (Livestock Survey, 2019). Therefore, one has to make necessary arrangements to provide balanced feeding to 535 million livestock in India in order to explore their optimum productivity. On this background, it is observed that presently animals are reared on crop residues and grazing on field boundaries, barren lands, inside and outside forest land with support of costly concentrate to milch animals on one hand and without concentrate growing and other animals on the other hand. Secondly, the another major source of grazing and forest lands in providing fodder to animals are also declining at the rate of 1.5 million ha per year due to one or other reasons.

Soybean is a leguminous oil rich and high proteinous crop and every part of this crop is useful to animals. However, soybean straw is highly lignified, fibrous in nature which reflects on its palatability, otherwise the principle value of soybean lies in its high content of digestible protein, digestible fat and rich source of minerals. It seems therefore necessary to have the efforts for increasing the palatability of the straw by adopting different techniques. Hence, it becomes necessary to divert this roughage for animal feeding and thereby reducing the gap between supply and demand of roughage. The effects of feeding urea treated SBS diet to growing calves have not been observed in past as evident from the documentation in literature. In general, the results on feeding untreated SBS diet to calves are encouraging (Adangale et al., 2009). Therefore, the efforts have been made to undertake the study on feeding urea treated soybean straw diet to calves in relation to their growth performance.

Materials and Methods

The present investigation entitled was conducted at Livestock Instructional Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, for a period of 90 days. The object of the experiment was to observe the utilization of soybean straw when treated with urea in the ration of calves and its impact on growth and economy. Akola comes under hot climate area of the tropical region. During summer season, the maximum ambient temperature reaches to 42 to 45 0c with the humidity ranging from 11 to 16 per cent. Twenty descript calves ranging from 60 to 90 kg body weight and 7 to 11 months age was selected and divided into four groups. The randomly divided groups were subjected to four different feeding treatments. The differences between the groups with regards to body weight and age were non-significant.

Soybean straw (SBS) was given urea treatment at the rate of 1.0, 1.5 and 2.0 per cent. The feeding of untreated SBS was designated as control. Urea was used for improving the nutritive values, palatability and to weaken the outer wall and to increase the digestibility of the SBS. The treated soybean straw was stored at 40 % moisture level with filled in the thick plastic bags and covered with tarpoline cloth by 28 days for incubation in anaerobic condition. The four different treatments consist of untreated soybean straw (T1), 1.0 % urea treated Soybean straw (T2), 1.5 % urea treated Soybean straw (T3) and 2.0 % urea treated Soybean straw (T4). The DCP and TDN requirements were fulfilled by feeding SBS, Hybrid Napier and concentrate mixture.

The calves were given computed quantity feed and fodder. The dry matter and water intake of individual animal was recorded twice in a week. Body weights of the experimental animals were recorded at the start of experiment and later on at weekly interval before feeding and watering in between 8 to 9 AM. At the start of experiment the animals were weighted on two consecutive days and its average was obtained to assess the actual weight of the animals. The digestibility trial was conducted at the end of thirteen weeks trial. The digestibility trial was conducted for a period of 14 days, out of which first seven days were preliminary period and rest of seven days as collection period.

The calves were offered measured quantity of feed and leftover was measured. During collection period the dung voided in 24 hours by individual calf was collected manually and measured to know the weight of dung voided. Individual sample of dung was collected and kept for DM estimation every day. All the seven days dried samples of individual calf were mixed together to form composite sample for analysis of proximate principles. The data were analyzed statistically by applying design as per the procedure given by Amble (1975).

Results and Discussion

Plane of Nutrition

Plane of nutrition of calves as influenced by different feeding treatments in terms of availability of digestible nutrients in comparison to their recommended level was worked out in order to assess whether the requirements were fulfilled or otherwise. The intake of required nutrients had direct impact on performance of calves. With this view, daily intake of DM, DCP, TDN and ME (Mcal) in calves were calculated under different treatments and are shown in Table 1

Table 1: Plane of nutrition of calves in relation to recommended level under different feeding treatments

Treatment	Avg. BW (kg)	Actual nutrient intake (kg)				Recommended level (kg)				% Excess/deficient			
		DM	DCP	TDN	ME (Mcal)	DM	DCP	TDN	ME (Mcal)	DM	DCP	TDN	ME (Mcal)
T_1	78.56	2.857	0.188	1.637	5.893	2.514	0.187	1.51	5.436	+13.64	+0.53	+8.41	+8.41
T_2	80.28	3.178	0.225	1.824	6.566	2.568	0.194	1.58	5.688	+23.75	+15.9	+15.44	+15.44
T_3	78.65	2.863	0.203	1.620	5.832	2.516	0.187	1.50	5.400	+13.79	+8.56	+8.00	+8.00
T_4	81.54	2.661	0.200	1.540	5.544	2.609	0.194	1.59	5.724	+1.99	+0.50	-3.14	-3.14

It was observed that intake of DM, DCP and TDN was higher than recommended levels in all the calves. However, the rate of consumption was more on 1.0 % urea treated SBS diet over the rest of the treatments. The calves from T_2 treatment consumed 23.75, 15.98 and 15.44 per cent more DM, DCP and TDN, respectively than that of their recommended level while the corresponding higher intake of 13.64, 0.53 and 8.41 %, respectively was observed in calves on feeding untreated SBS diet. However, surprisingly it was noted that the calves fed with 2.0 % urea ammoniated SBS diet (T_4) received marginally less (3.14 %) TDN in reference to their recommended requirements, though these calves consumed 1.99 and 0.50 % more DM and DCP over that of their requirements. This situation might have emerged out on the fact that the T_4 calves consumed less DM and ration was comparatively lower in TDN contents. However, it appears that the lower intake of TDN in T_4 calves was not of a substantial level to influence adversely the optimum growth performance in them, while probably the factors like higher DMI and higher CP digestibility in feeding of 1.0 % urea treated ration to calves might be the reason to increase substantial the DM, DCP and TDN intakes in them. Moreover, the calves from T_2 treatment received 6.566 ME (Mcal) which seems to be higher by 15.44 % than recommended level (5.688 Mcal), while intake of energy in T_4 calves was found slightly lower (3.14 %) than recommended level. On the other hand the intakes of energy in calves on T1 and T3 treatments were higher by 8 to 8.41 % than their respective recommended levels. Also, the results of present investigation are observed similar by the results reported by previous research workers like Ahmad et al. (2017) and Akhter et al. (2017) on buffalo calves and crossbred bull calves.

Table 2 : Details of digestibility of different nutrients

Sr. No	Particular	Nutrient	T_1	T_2	T_3	T_4
1	Average body wt(kg)		78.56	80.28	78.65	81.54
2	DMI/day (kg)		2.857	3.178	2.863	2.661
3	Daily nutrient intake (kg)	CP	0.304	0.355	0.340	0.339
		CF	0.984	1.099	1.005	0.930
		EE	0.051	0.056	0.053	0.050
		NFE	1.209	1.292	1.137	1.026
4	Average daily dung (kg)		5.80	6.10	5.09	5.93
5	DM in dung (%)		20.46	19.78	22.45	17.85
6	Daily nutrient voided in dung (kg)	DM	1.187	1.207	1.143	1.059
		CP	0.116	0.131	0.105	0.140
		CF	0.406	0.430	0.391	0.348
		EE	0.016	0.017	0.018	0.016
		NFE	0.418	0.407	0.389	0.350
7	Daily nutrient retention (kg)	DM	1.670	1.971	1.720	1.602
		CP	0.188	0.224	0.235	0.199
		CF	0.578	0.669	0.614	0.582
		EE	0.035	0.039	0.035	0.034
		NFE	0.791	0.885	0.748	0.676
8	Digestibility coefficient (%)	DM	58.47	62.05	60.09	60.23
		CP	61.01	63.24	59.26	58.81
		CF	58.80	60.95	61.08	62.62
		EE	68.69	70.52	67.22	67.47
		NFE	65.42	68.48	65.69	65.87
9	Nutritive value (%)	DCP	6.60	7.07	7.09	7.51
		TDN	57.29	57.38	56.59	56.22

A reference to Table 2 indicated that the calves from all the treatments consumed more DM than that of their recommended levels (3.2 % BW). However, it was observed that the calves from T_2 treatment consumed significantly higher DM (3.178 kg) over that of other groups while, lowest consumption of (2.661 kg) DM in calves was noticed under T_4 group, whereas the intake of DMI / day in T_1 and T_3 groups was intermediate. Hence the trend does postulate that the calves from all the treatments might have received different nutrients adequately as per their recommended levels.

The calves reared on 1.0 % urea ammoniated SBS diet received more CP (0.355 kg) against the intake of CP in calves on feeding untreated diet. Moreover, the calves fed with 1.5 and 2.0 % urea ammoniated SBS diet also consumed more CP inspite of the lower DMI than that of untreated SBS group. However, the intake of CP between T_2, T_3 and T_4 did not differ significantly, indicating more or less similar CP intake on urea ammoniated SBS ignoring the level of urea treatment. On an average CP intake in calves was 0.304, 0.355, 0.340 and 0.339 kg/calf in T_1, T_2, T_3 and T_4 respectively.

With regards to intake of CF on different rations, it was noted that 1.0 % urea ammoniated SBS diet provided more quantity of crude fibre to calves (1.099 kg/day) over rest of the feeding treatments. Moreover, the calves from T_1, T_3 and T_4 received more or less equal amount of CF from the diet as the differences did not reach the level of significance, the intake being 0.984, 1.005 and 0.930 kg / day / calf respectively. In respect to availability of ether extract (EE) on different feeding treatments to calves, it is observed that, the calves from all the treatments received similar EE from the diet as the differences between the treatments were non significant. The overall intake of EE was 0.051, 0.056, 0.053 and 0.050 kg /day /calf under T_1, T_2, T_3 and T_4 respectively.All the feeding treatments were found at par in reference to providing Nitrogen Free Extract (NFE) to calves. On an average the intake of NFE was 1.209, 1.292, 1.137 and 1.026 kg /day /calf under T_1, T_2, T_3 and T_4 respectively. However, the calves from T_2 group received 6.86, 13.63 and 25.92 % more NFE nutrient from the diet over the intake NFE on T_1, T_3 and T_4 diet, respectively.

Thus the results on daily intake of different nutrients did indicate that treatment of urea ammoniation to leguminous SBS did not hamper nutrient intake in calves. On the contrary urea treatment proved a potential method to improve the acceptability of the lignified fibrous straw and thereby supply of different nutrients in sufficient quantity.

It is evident from Table 2 that the digestibility of different nutrients differed significantly between the treatments. The digestibility coefficient value of the DM was significantly higher in T_2 treatment over that of T_1 treatment. However, the differences in digestibility coefficients between T_1, T_3 and T_4 as well as T_2, T_3 and T_4 were found non significant. This means 1.0 % urea ammoniation to SBS resulted in increasing the DM digestibility over that of untreated diet.

With regards to digestibility of CP on different treatment diets, it was observed that significantly higher CP digestibility was noticed on T_2 treatment diet over rest of the treatments. The values being 61.01, 63.24, 59.81 and 58.98 % for T_1, T_2, T_3 and T_4, respectively.

In respect of CF digestibility on different treatments, it was observed that the digestibility coefficients differed significantly between treatments. Significantly higher digestibility of fibre was noticed on T_4 diet over the rest of diet, while the digestibility coefficients between T_1, T_2 and T_3 did not show significant differences. The overall average digestibility coefficients for CF were 58.80, 60.95, 61.08 and 62.62 % on T_1, T_2, T_3 and T_4 treatments, respectively. Saini et al (2007) observed improvement in the digestibility of CF as a result of urea ammoniation to leguminous straw like Berseem straw, Lentil straw and Cluster bean straw, respectively. These explanations could be attributed to present trend of higher CF digestibility in SBS treated with 2.0 % (T_4) urea over untreated and treated with lower per cent of urea (T_2 and T_3).In reference to ether extract (EE) digestibility of untreated and treated SBS diet, it was noticed that the EE digestibility decreased significantly with the increase level of urea ammoniation to straw. As a result the EE digestibility on T_3 and T_4 diet treated with 1.5 and 2.0 %, respectively were at par with that of EE digestibility on untreated SBS. However, The EE digestibility observed on 1.0 % urea treatment of SBS (T_2) was significantly higher over T_3 and T_4 treatment.On the other hand, NFE digestibility did not exhibit significant differences between T_1, $T_3$and T_4 treatment, while NFE digestibility on T_2 treatment was found significantly more over rest of the treatments. This means the increase level of urea ammoniation to leguminous SBS adversely affected the NFE digestibility.

The past workers like Baswade et al. (2007), Adangale et al. (2008) and Mule et al. (2008) reported DM, CP and CF digestibilities of SBS diet in crossbred male calves, buffalo heifers, kids, crossbred calves and kids, respectively in the range 50.15 to 56.64, 50.76 to 56.38 and 51.10 to 55.60 %, respectively. Pachauriet al. (2010) are in agreement with present results as they reported higher digestibility of nutrients on feeding of urea treated wheat straw ration to calves. Thus in general results indicated that feeding of urea ammoniated SBS to calves had no adverse effect on availability of different nutrients to calves. On other hand urea treated SBS diet provided more amounts of DM, CP and CF to calves in comparison to untreated SBS rations. Also, the results of present investigation are observed similar by the results reported by previous research workers like Ahmad et al. (2017) and Akhter et al. (2017) on buffalo calves and crossbred bull calves.

Conclusion

On the basis of data obtained in the present study it is concluded that,the results on nutrient intake in relation to requirement as per feeding standards indicated that all the calves except T_4 group received higher quantity of DM, DCP and TDN over their requirements. The excess consumption in T_1, T_2 and T_3 calves were 13.64, 0.53 and 8.41, 23.75, 15.98 and 15.44, 13.79, 8.56 and 8.00 % DM, DCP and TDN, respectively. Whereas, the calves from T_4 group received marginally less (3.14 %) TDN in reference to their recommended requirements though, the calves consumed 1.99 and 0.50 % more DM and DCP over that of requirements. Hence, the results calls upon the need of increasing DMI in calves when they are fed with higher level urea treated SBS. The feeding value in terms of DCP and TDN increases with the increase level of urea treatment of SBS from 1.0 to 2.0 per cent.

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Quantifying Response of Pre-released Kharif Grain Sorghum Genotype to Different Fertility Levels under Dry Land Condition

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Abstract: Field experiment was conducted on *kharif* grain sorghum at Sorghum Research Unit, Dr. PDKV, Akola, MS during *2018* and 2019 under rainfed condition to find out the performance of promising *Kharif* sorghum hybrids to fertilizers interaction. The experiment was laid out in factorial randomized block design with three replications. Test entries SPH-1846, SPH-1849 (2018) and SPH-1883, SPH-1886 (2019) were tested with the respective checks viz, CSH-16, CSH-25 and CSH-30) for their response to the three different fertilizer levels (F_1 - 75 % RDF, F_2 - 100 % RDF and F_3 - 125 % RDF). During 2018-2019, test genotype SPH-1846 (2018) and SPH-1886 (2019) recorded the highest values for highest plant height (cm), grain weight per panicle (g), grain number per panicle , weight of cob and length of panicle (cm). With the fertility level, growth and yield contributing character were found significantly maximum with application of fertilizer with $\mathbf{F_3}$. 125 % RDF.

Among the different four tests and three check genotypes, hybrid SPH-1846 (2018) and SPH-1886 (2019) were recorded the significantly highest grain yield ,fodder yield and biological yield. Among the three different fertility levels, application of 125 % RDF ($\mathbf{F_3}$), recorded the significantly highest grain yield , fodder yield and biological yield over the fertilizer levels - 75 % RDF ($\mathbf{F_1}$). The fertilizer application with $\mathbf{F_2}$: 100 % RDF recorded the second highest grain, fodder and biomass yield, which was found on par with application of 125 % RDF ($\mathbf{F_3}$). Interaction effect found significant for grain, fodder and biomass yield. Significantly highest monetary advantage and B:C ratio was found with the test genotype SPH-1846, SPH-1886 and fertility level 125 % RDF.

Keywords **:** Sorghum, Fertility level and Genotype.

Introduction

Sorghum (*Sorghum bicolor* L.), is one of the most important cereal crops in India. It is the fourth most important cereal crop of the world. It occupies a major niche in the many semi-arid subtropical farming systems due to its low cost of production and better response to favorable conditions with high yield. In addition, it is a double purpose crop; as a fodder and grains. The low productivity of sorghum is primarily because it is often grown on marginal lands with low N, P, K by resource poor farmers. The availability of high yielding and fertilizer responsive cultivars of sorghum has injected new enthusiasm in fertilizer research. Therefore, it is important to assess the magnitude of their response to fertility levels and simultaneously find out the production potential. This encouraged us to investigate the response of promising sorghum cultivars to split application of nitrogen. Nutrient uptake of sorghum was higher at optimum N,P, K in the root zone depth which enhances the better crop yield and its components and chemical contents. Similar results were reported by Mokashi *et al.* (2008) and Akdeniz *et al.*, (2000).

Low productivity of sorghum is one of the major constraints. Reasons for which are identified as lack of improved high yielding cultivars, delayed sowing, low fertilizer use and improper adoption of management techniques. Nitrogen is the essential element required for plant growth in relatively large amounts. However, deficiencies of nitrogen are common. Nitrogen deficiency can result in reduced dry matter, crude protein and grain yield (Jarvis, 1996; Ashiono *et al.*, 2005). Soil nutrients become depleted due to leaching of nitrogen, soil erosion and removal by crops (Zobeck *et al.*, 2000). In India, the area under sorghum is approximately 5.30 million hectares with an annual production of about 5.05 million tonnes and an average productivity of 953 kg ha-1 (Anonymous, 2016). Sorghum is mainly grown in Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan. The production can be increased by adopting improved package including suitable genotype, optimum plant geometry and appropriate fertilization. Hence, there is dire need to identify high yielding cultivars suitable for the region with optimum fertilizer dose. Sorghum cultivars are known to vary in their response to fertilizers. Productivity of sorghum is limited by soil fertility. Kumar *et al.*, (2010) reported that the increase in productivity of sorghum could be brought out both by genetic improvement as well as associated nutrient management intervention in a rainfed environment.Optimum dose of nitrogen, phosphorous and potassium is dependent on several factors like soils, crop, environment and crop growing situations, further genotype plays an important role in increasing crop production but information on the response of newly evolved genotypes/ varieties to nitrogen, phosphorous and potassium levels is meager. The development of elite genotype is a continuous process and currently many genotypes of different maturity groups have been evolved. Hence, there is a need to explore and evaluate the interaction of sorghum cultivars and fertilizers application in rainfed sorghum. The present study was planned to quantify the response of sorghum cultivars to fertilizer levels and so as to develop best management practices under rainfed conditions to achieve higher yields with low cost of production.

Materials and Methods

The field experiments was carried out at the Sorghum Research Unit Farm, Dr. PDKV, Akola of Maharashtra during 2018 and 2019. The experimental site is between latitudes 23° 43' N and 77 ° 64' E longitudes with an altitude of 281 m above mean sea level. The experiments were carried out during two successive kharif seasons of 2018 and 2019. The response of sorghum cultivars Viz, SPH-1846, SPH-1849, CSH-16, CSH-25 and CSH-30 (2018) and also genotype SPH-1883, SPH-1886, CSH-25 and CSH-30 (2019) were studied with the three different fertilizer levels (*F_1:75 % RDF, F_2:100 % RDF and F_3:125 % RDF*) under rainfed conditions. Among the cultivars SPH-1846, SPH-1849, SPH-1883, SPH-1886 is the test hybrids and CSH-16, CSH-25 and CSH-30 are the check inbred lines. The different genotype and three different fertilizer levels were laid out in a factorial randomised block design with three replications. Soil samples collected before cultivation and analyzed for physical and chemical properties analysis whereas, soil pH of experimental site was found to be vary from 8.27 to 8.31, available nitrogen 181 to 189 Kg ha^{-1}, available phosphorus 20.00 to 22.30 Kg ha^{-1} and available potassium 317 to 331 Kg ha^{-1} were observed in the first and second seasons respectively. The seasonal mean temperature ranged between 28.0° C to 36.0 ° C (Max) and 18.1° and 24.6° (Min) during both the year. Total rainfall received during 2018 and 2019 were 839.5 and 930.2 mm distributed over 40 and 56 rainy days, respectively.

Seeds of sorghum cultivars used for sowing which was obtained from Indian Institute of Millets Research, Hyderabad. Normal cultural practices for sorghum were applied as recommended till harvest. The recommended dose of fertilizer was 80-40-40 N-P_2O_5-K_2O kg ha^{-1}. The fertilizer sources used were through urea for N (46 % N), single super phosphate for P (16 % water soluble P_2O_5) and muriate of potash for K (60 %). As per the treatments, entire dose of P and K and half of the N were applied at the time of sowing as a basal dose, remaining dose of N was applied at 30 DAS as top dressing. Seed rate was 10 kg ha^{-1} and sown manually on 30.06.2018 and 01.07.2019 with a spacing of 45 cm between rows and 15 cm between plants. The plot area was 15.84 m^2 (3.60 m length × 4.40 m width). Plants were thinned to a single plant per hill maintaining distance between the plant 15 cm apart. The growth and yield parameters as well as yield at harvest were recorded as per standard procedures. The amount of inputs and outputs per hectare were multiplied with a wage or price of the unit to consolidate all of them in one unit (Rs ha^{-1}) to find out the economic indices *viz*., total cost of production, gross returns, net returns and benefit cost ratio. The data were analysed statistically by using analysis of variance according for a factorial randomised block design (Two factors) (Gomez and Gomez 1984) and the differences of means were identified by critical difference (CD) at $P \geq 0.05$.

Results and Discussion

1. Effect of cultivars on growths and yields contributing components of *Sorghum bicolor*:

Data pertaining to the growth and yield parameters is presented in table 01. The analysis of data and results showed that, plant height (cm), days to 50 % flowering, 100 seed weight (g), grain weight per panicle (g), grain no. per panicle and length of panicle (cm) found significant due to the performance of Test and Check Sorghum hybrid during 2018-19 and 2019-20.

During 2018-19, among the different two test and three check genotype, significantly highest plant height (cm), grain weight per panicle (g), grain no. per panicle and length of panicle (cm) were recorded with the test hybrid SPH-1846 and it was found at par with the test hybrid SPH-1849 and check hybrid CSH-25 for plant height and grain weight per panicle. However, days to 50 % flowering and 100 seed weight differ significantly due to the Check hybrid CSH-30 and found at par with test hybrid SPH-1849. Days to 50 % flowering were significantly varied with test and check hybrid genotypes, among all the check CSH-30 recorded lowest days to 50 % flowering and in test hybrid SPH-1849 recorded minimum days to 50 % flowering. Whereas weight of cob (g) recorded highest with SPH-1846, but did not differ significantly with the performance of test and check genotype. Among all the genotype, test hybrid SPH-1846 recorded significantly superior values for Length of panicle (cm) over all other genotype.

Table 01: Main effect of genotype on yield components of *Sorghum bicolor* in the two growing seasons

Genotypes	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
2018-19							
SPH-1846	178.96	71.56	2.08	40.02	82.11	1918	29.73
SPH-1849	173.83	70.44	2.35	38.57	76.96	1646	24.81
CSH-16	171.67	71.56	2.23	37.97	59.29	1712	26.18

Genotypes	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
CSH-25	176.83	74.67	2.23	39.04	68.82	1757	26.84
CSH-30	167.67	69.00	2.38	33.00	61.09	1393	22.98
SE (m) ±	2.48	0.53	0.05	1.04	8.38	52	0.67
CD at 5 %	7.18	1.55	0.15	3.00	NS	150	1.94
				2019-20			
SPH-1883	166.30	66.28	2.49	29.02	80.13	1160	25.89
SPH-1886	191.10	69.22	2.81	**33.52**	81.90	1191	25.90
CSH-25	189.00	73.00	2.90	22.34	61.33	771	19.22
CSH-30	179.15	66.27	2.59	30.58	67.80	1173	21.31
SE (m) ±	3.27	1.07	0.05	1.00	7.49	35	0.78
CD at 5 %	9.54	3.11	0.14	2.91	NS	102	2.28

During 2019-20, among the different two tests and two check genotypes, significantly highest plant height (cm), grain weight per panicle (g) and grain no. per panicle were found significantly highest with the test hybrid SPH-1886. Plant height values were found at par with the check hybrid CSH-25, in case of grain no. per panicle was found at par with check hybrid CSH-30 and test hybrid SPH- 1883 but, grain weight per panicle; it was found significantly superior over all other genotypes. However, Days to 50 % flowering differ significantly due to the check hybrid CSH-30 and test hybrid SPH – 1883 and recorded minimum days to 50 % flowering. The 100 seed weight was found significantly highest with check genotype CSH-25 and it was found at par with test genotype SPH- 1886. Whereas, length of panicle and harvest index recorded significantly highest with SPH-1883 and it was found at par with SPH- 1886. Among all the genotype, test hybrid SPH-1886 recorded significantly superior values for grain weight per panicle over all other genotype.

In general, genotype SPH- 1846 (2018-19) and SPH-1886 (2019-20) were recorded maximum plant height of 178.96 cm and 191.10 cm, respectively compared to other test and check genotype. The variation in plant height in sorghum varieties at different levels of fertilizer application was also earlier reported by George Yakubu Mahama (2012). Among the all genotype, variation was obtained with plant height, grain weight per Panicle (g), grain no. per Panicle and Length of Panicle (cm).

2. Effect of different Fertility Levels on growths and yields contributing components of *Sorghum bicolor*:

During the succeeding two growing seasons (Table 2), the yield of sorghum and its attributes; exhibited significant differences for different fertility levels. During 2018-19, Plant Height (cm), 100 Seed Weight (g), Grain Weight per Panicle (g), Grain No. per Panicle and Harvest Index (%) were found significantly maximum with F_3 fertility levels (125 % RDF). However, it was found at par with the application of 100 % recommended dose of fertilizer (F_2). Among all the fertility levels, F_3 fertility levels recorded significantly superior values for grain weight per panicle. The significantly minimum days to 50 % flowering was recorded with F_3 and found at par with F_2. However, length of panicle was found highest with F_3 level but did not differ significantly due to the different fertility levels.

Table 02: Main effect of fertility levels on yield components of *Sorghum bicolor* in the two growing seasons

Fertility levels	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
				2018-19			
F1 -75 % RDF	168.64	72.20	2.22	33.20	57.39	1510	24.87
F2 -100 % RDF	173.00	71.33	2.22	38.92	73.25	1762	26.37
F3 -125 % RDF	179.73	70.80	2.32	41.05	78.32	1783	27.09
SE (m) ±	1.92	0.41	0.04	0.80	6.49	40	0.52
CD at 5 %	5.56	1.20	NS	2.32	NS	117	1.51
				2019-20			
F1 -75 % RDF	174	70.19	2.60	24.51	54.10	944	22.43
F2 -100 % RDF	184	68.86	2.69	29.68	58.11	1110	22.80
F3 -125 % RDF	186	67.03	2.80	**32.40**	59.22	1168	23.55
SE (m) ±	2.83	0.92	0.04	0.86	5.22	30	0.68
CD at 5 %	8.27	2.69	0.12	2.52	NS	89	NS

Table 06: Interaction effect of cultivars and fertility levels on yield and economics sorghum during 2018-19 and 2019-20 seasons.

Genotypes * Fertilizer	Grain Yield q ha^{-1}	Fodder Yield q ha^{-1}	Biomass Yield q ha^{-1}	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})
Interaction Genotypes x Fertilizer					
2018-19					
CD at 5 %	6.85	30.00	30.04	13117	13117
2019-20					
CD at 5 %	7.52	22.00	24.55	14789	17489

5. Interactions between cultivars and fertilizer levels:

The interaction effect between cultivars and different fertility levels (Table 05 and 06), data shown significant effect on plant height (cm), days to 50 % flowering, grain weight per panicle (g), grain number per panicle, length of panicle (cm), grain yield (kg ha^{-1}), fodder yield (kg ha^{-1}), biomass yield (kg ha^{-1}), GMR and NMR (Rs ha^{-1}) during 2018-19. The data obtained from second season showed that, grain weight per panicle (g), grain number per panicle, grain yield (kg ha^{-1}), fodder yield (kg ha^{-1}) biomass yield (kg ha^{-1}), GMR(Rs ha^{-1}) and NMR (Rs ha^{-1}) recorded significant impact. The obtained data showed that increasing fertility level from 75 % to 125 % RDF and genotype SPH-1846 (2018-19) and SPH – 1886 (2019-20) together led to an encouragement in grain formation owing to increasing the plant capacity in building metabolites and caused increase in grain and head weight. Application of 125 % RDF under rainfed sowing genotype SPH-1846 (2018-19) and SPH – 1886 (2019-20) gave maximum grain yield, Fodder yield, biological yield, GMR, NMR and B:C ratio.

Conclusion

It could be concluded from the experimental data that sowing of sorghum crop (Sorghum bicolor L.) genotype SPH-1846 (2018-19), SPH – 1886 (2019-20) and fertilized by 125 % Recommended Dose of Fertilizers were observed in order to raise a healthy and good sorghum crop and ultimately get the highest yield and monetary returns under dry land condition of Vidarbha . The application of 125 % RDF (F_3) recorded significantly higher grain yield and fodder yield as compared to rest of the fertilizer levels. Among the genotypes SPH-1846 (2018-19) and SPH – 1886 (2019-20) produced more grain, fodder yield, GMR and NMR as compare to other genotypes only they were at par with each other.

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Mechanical Harvesting of Green Pea Pods: A Review

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Abstract: The green pea (*Pisum sativum* L.) is popular crop of India and belongs to *Fabaceae* family. Pea also holds a prominent place among vegetables due to its high nutritive value, particularly proteins and other health building substances like carbohydrates, vitamin A, vitamin C, calcium and phosphorus. It contains a good proportion of essential amino acids particularly lysine and is a cheapest source of protein in diet. Major source of protein for large population of India come from vegetables. This makes green peas, alongside different vegetables, a vital nourishment asset in the nation. India isn't just the biggest consumer of green peas, yet in addition it takes second place in worldwide green pea cultivation, following China. The popular varieties of green pea in Punjab and India are AP-3, Matar Ageta-6, Arkel, Punjab 89 and Mithi Phali. Presently, green pea crop is cultivated on approximate thirty-five thousand hectares in Punjab. Out of this 90% area is cultivated under early maturing variety of green pea. Picking of green pea is labor intensive. A volume of labor is required for multiple picking and it costs Rs 3-4/kg for harvesting pods. Therefore, to lower the involvement of manual labor, mechanized picking of pod is required. To increase the area under cultivation of green peas in Punjab, the state government has imported a pea harvester cum-de-podder from Holland for Rs. 3.50 crore. This machine harvest and de-pods the green pea and transports the pea grains to its hopper. The initial capital cost of this machine is very high and the size of this machine is also very large which makes it uneconomical for Punjab farmers. This machine can't be operated on pea crop sown on ridges, but the farmers of the Punjab state prefer to sow their crop on the ridges.

Keywords: Green peas, mechanized picking, labor intensive, harvest.

Introduction

The green pea (*Pisum sativum* L.) is popular crop of India and belongs to *Fabaceae* family. Pea also holds a prominent place among vegetables due to its high nutritive value, particularly proteins and other health building substances like carbohydrates, vitamin A, vitamin C, calcium and phosphorus. It contains a good proportion of essential amino acids particularly lysine (Ghobary, 2010) and is a cheapest source of protein in diet. Major source of protein for large population of India come from vegetables. This makes green peas, alongside different vegetables, a vital nourishment asset in the nation. The popular varieties of green pea in Punjab and India are AP-3, Matar, Ageta-6, Arkel, Punjab 89 and Mithi Phali. Developed seed is very nutritive and contains high extent of edible protein, starches, minerals and vitamins. Green peas are available from September onwards till February. The northern and central parts of India are the main territories of green pea production.

India is not just the biggest consumer of green peas, yet in addition, it takes second place in worldwide green pea cultivation, following China. The major producer countries are China, India, United States, France and Egypt (Singh *et al* 1983). In addition, India is the world's largest green pea exporter. Major export destinations of green peas from India are UK, Russia, Saudi Arabia, UAE, Nepal and Qatar. In the year 2017-18 India has exported 410.11 MT of green peas to its destination countries, which holds the value of about Rs. 17.94 million (Anon 2018a). The area under peas in India was 530.5 thousand hectares in 2016-17, which, increased to 540.5 thousand hectares in 2017-18. The production and productivity of green peas was 5345 thousand MT and 10.1 MT/ha in 2016-2017, respectively, while the corresponding figures for 2017-18 was 5422.1 thousand MT and 10 MT/ha, respectively (Anon 2018a). The area under green peas in Punjab was 35.38 thousand hectares in 2016-17, which, increased to 37.62 thousand hectares in 2017-18. The production and productivity of green peas were 366.43 thousand MT and 10.36 MT/ha in 2016-2017, respectively, while the corresponding figures for 2017-18 were 394.00 thousand MT and 10.47 MT/ha, respectively (Anon 2018a). In Punjab state, Amritsar and Hoshiarpur districts are major producer and cultivators of green pea. The area under green peas in Amritsar and Hoshiarpur was 17.59 and 6.21 thousand hectares, respectively, producing about 188.51 and 61.54 thousand MT, respectively in 2016-17.

Agro-climatic conditions are imperative while planting green peas; it decides the time of sowing, position in the crop rotation. Green peas develop best in damp and cool weather. It is a cool-season trim grown in numerous parts of the world. Planting can be done from winter to late-spring contingent depending upon the place. Perfect temperature for green pea production is between 10°C to 30°C, the higher temperature may bring about poor yield. Green peas can be developed in wide assortment of soils. Green pea develops best in drained soils with pH scope of 6-7.5 (Anon 2018b). Soils with great organic matter will bring about great yields and quality of the produce. The production of pea requires regular irrigation. Each irrigation ought to be done at on 8-10 days interval. Generally, the green pea is cultivated on ridges. The ridge to ridge spacing is kept about 67.5 cm and two rows of pea are sown on either side of ridge at a spacing of 25.4 cm.

Pea cultivation is popular among farmers due to short duration and fitting well between crop rotations of rice/maize-wheat, rice/maize-spring maize, rice/ maize-summer moong, rice/maize-sunflower, rice/maize-cucurbits and rice/maize-onion. Its cultivation improves soil health by fixing atmospheric nitrogen. Presently, green pea crop is cultivated on approximate thirty five thousand hectares in Punjab. Out of this 90% area is cultivated under early maturing variety of green pea. Generally, early maturing variety of paddy is cultivated between the month of June to September and late sown variety of wheat is cultivated from December onwards by pea growers. The available time between mid-September to mid-December, in paddy/wheat system the early maturing variety of green pea are grown, which fetches more price because during this time supply of pea is less and demand is more.

Picking of green pea is labor intensive. A volume of labor is required for multiple picking and it costs Rs 3-4/kg for harvesting pods (Anon 2017). Therefore, to lower the involvement of manual labor, mechanized picking of pod is required. To increase the area under cultivation of green peas in Punjab, the state government has imported a pea harvestercum-de-podder from Holland for Rs. 3.50 crore. This machine harvest and de-pods the green pea and transports the pea grains to its hopper. The initial capital cost of this machine is very high and the size of this machine is very large which makes it uneconomical for Punjab farmers. This machine can't be operated on pea crop sown on ridges, but the farmers of the Punjab state prefers to sow their crop on the ridges. Also keeping in view the farm size of Punjab state, small size tractor operated pea pod harvester is required.

In agriculture, timeliness in farm operations, especially the harvesting the crop is very crucial. In this paper, the literature concerning to research carried out in the area of pea pod harvesting and picking has been reviewed and presented under the heads as mentioned below.

1. Development of different pea harvester
2. Performance evaluation of harvester
3. Harvesting losses of harvester

1. Development of different pea harvester

Johnson (1906) invented pea harvesting machine for harvesting dry pea. The vines were cut from plants and passed to threshing cylinder. The peas and vines are transported by continuous belt conveyor after threshing carried out in cylinder. From continuous belt conveyor peas delivered to beating cylinder which will separate pods & vines and pods are discharged through the machine. The peas are passed through screen and collected in receiving chamber.

Pritchard (1914) invented pea thresher and harvester adapted to be drawn over the field. It was provided with suitable guide elements to direct the vines properly to the machine. Beaters which were rotating transversely to the direction of travel to strip the vines. An arrangement of raking elements and forks was also provided and driven as to cause the threshed peas to be delivered into a chamber which is situated at the back side of the machine.

Arbuckle (1936) invented combined pea harvester and huller to provide an improved machine for cutting the standing vines and hulling the peas, as the machine travels in the field. This machine delivers the vines and hulls back onto the field. It separately retained the shelled peas for canning. It deposits the vines, shells and chaff back into the field, where they can be ploughed under for manure, if desired, or cured for hay and used as animal stock food. The objective of this invention was to provide a combined harvesting and hulling machine. It was provided with a number of hulling drums to give the machine sufficient capacity to quickly harvest and hull the peas in a field, which leads harvesting in short period.

Kerr (1940) developed a bean harvesting device. This invention was related to improvements in bean cutting machines for cutting string beans along their length or shoestring beans for canning or other treatment. The objective of machine was to develop a bean orienting device for bean cutting machines. The bean orienting device arranges the beans lengthwise with respect to the cutting mechanism. It was provided with a feeding mechanism for maintaining the beans, arranged lengthwise with respect to the cutting mechanism.

Coons (1952) invented pea harvesting and threshing machine for shelling green peas, beans, or other legumes. It was particularly applicable to legume-shelling mechanism of a mobile harvesting machine. It combines shelling mechanisms with automatic cutting systems for cutting the vines in the fields. It was equipped with conveyor elevators for delivering the cut vines to the shelling mechanism, where they were processed to recover the pea grains. It reduces contamination of the peas, by the juices of the vines. It protects peas from bruising, splitting, or crushing. Due to its large capacity, compactness of construction and mobility, this machine was efficient pea shelling machine.

Ritter *et al* (1952) invented automatic leveling bean and pea harvester. This machine was used for collecting the vines and separating the peas, beans or similar pod crops from the vines, as the machine moves forward on the field. It simplify and facilitate the stripping of the beans and peas from the vines in an efficient and economical manner, providing means for gathering the vines and feeding them to the rotary drum and the shelling beaters, as the machine was operated between rows of the vines growing in the field. The detached beans falling on the sieve drum are transported by a separating conveyor to a receiving chamber of the machine. The vines and open pods were uniformly discharged on the ground.

Grether (1953) invented a bean picker to pick a greater percentage of pods directly from stalks and leaving the stalks in the soil. This was accomplished by providing a mechanism for stripping pods from the stalks and allowing the pods to fall on the ground. After that pods fallen on the ground were collected. The other method of picking beans comprises cutting whole stalk off, gathering bean stalks and transporting them to a place, where stalks and bean pods can be separated.

Carruthers (1956) developed a machine for separating and harvesting pod type crops. The principle of this machine was to cut and separate the pods from the vines and leaves. This machine was used to harvest green beans, wax beans, soybeans, lima beans and okra. The main objective of this study was to protect the peas at all steps from exposure to sun, air and dust just before the peas being placed in cans or freezing container. It includes the steps of cutting the pods, leaves and vines from the stems of the matured plants, cutting the leaves and vines from the pods and at last separating the pods from the leaves and vines. Another objective of this study was to transport the pods substantially free from leaves to the freezing plant or canning, and at the same time protecting the peas from the harmful effects of weather conditions and exposure of peas to the heat and dust.

Goodad (1959) developed a pea harvester. This research was related to advancement in pea pod harvesters and deals with the device for separating peas from the vines and pods, receiving the pea grains in a receiver and leaving the vines and pods. It separates pea grains from pea pods. In this machine the vines were eradicated from the ground, next a conveyor conveys the vines and pea pods to the continuous conveyor thresher which separates the pea grains from the pods. The pea grains falls onto a belt conveyor, this delivers them to a storage container. This study consists of provision of a device for economical harvesting of peas which could be operated by unskilled labor.

Gunkel and Anstee (1962) assessed an improvised row crop header. Rubber fingers connected to v-belts were provided to sift through the vines and the lift beans over a reciprocating cutter bar. Two funnel-shaped, rotating brushes were later added to this machine and fixed on each side of the row to strip the pods up vertically. Amid testing the brushes were choked up with plant material.

Maffei (1970) developed a bean pod picking equipment which moves along a row of bean plants. It was having a front end and a plant receiving zone extending longitudinally through which a row of plants passes as it moves. A picking mechanism was situated next to the receiving zone. This mechanism consist of one or more beaters which passes through the plant receiving zone with a rotary beating action by which beans are separated and thrown from the picking zone to a gathering conveyor. The beating action of rotary beater has found to be very efficient in providing complete picking of beans without uprooting the plants. It stripes the plant in stages, first stripping the top portion of the plant and finally stripping the bottom remaining portion of the plant.

Csimma (1967) developed a vine crop harvesting machinery. The objective of this study was to develop a self-propelled harvesting machine for collecting and separating the vines and fruits. An arrangement was provided for conveying the harvested vines and other material through the machine. Manual sorting operation was facilitated and output of the machine was increased. Other objective of this study was to assure gentler handling of the delicate fruits and to increase the efficiency of the machine ultimately reducing the fatigueof the labors caused by manual for harvesting.

Towson and Lewiston (1976) developed a pod combine. A pod combine consists of a harvester and a thresher mounted on a self-propelled mobile structure. The harvester stripes out the unopened pods and a portion of the leaves from the plants. An inclined continuous belt conveyor conveys the harvested material through a cluster separation assembly which separates clusters of leaves and pods and distributes them evenly on a belt conveyor. An aspiration system was provided which sucks out the leaves from the pods and the pods later on conveyed to the thresher. The thresher consists of reel and an axially fixed impeller having number of beaters. The grain collecting device was fixed below the reel.

Behroozi and Huang (2002) designed and developed chick-pea combine. A specially designed tractor drawn machine (P-Combine) was developed to suit the harvesting conditions. The P-Combine simultaneously performs the tasks of: (1) picking of pea pods; (2) threshing peas out of the pods; (3) cleaning and separation, and; (4) unloading the cleaned peas. The machine was tested in the field with good results. Although further improvement was needed to reduce the high head losses. A field capacity of 0.35 ha/h was achieved. The total power requirement was 13.7 kW.

2. Performance evaluation of harvester

Goss *et al (*1958) evaluated performance characteristics of the combine in barley crop. It was found that the ratio of rpm to forward speed should be 1.25 to 1.5 in upright crops. It was also observed that at higher ratio there is increase in shattering losses. On decreasing the cylinder and concave clearance the reduction in the cylinder losses was observed.

Zyla *et al* (2002) designed and evaluated a new crop lifter for harvesting dry bean. During preliminary laboratory evaluation it was reported that effectiveness of pod lift by the bristle-guards was dependent on pod orientation with respect to the plant stem and travel direction of harvester. A significant difference between the single bat and double bat designs was not detected at 5% level of significance during field test. Gathering losses varied from 15-24 % for bristle-guards, for standard guards it varied from 26-33%. A series of bristles mounted to the cutter-bar guard and was positioned perpendicular to the direction of harvester travel in crop lifter. Losses were reduced as bristles lift and tilt low hanging bean pods away from the plant stem preventing them from being cut. Losses were 15% of yield.

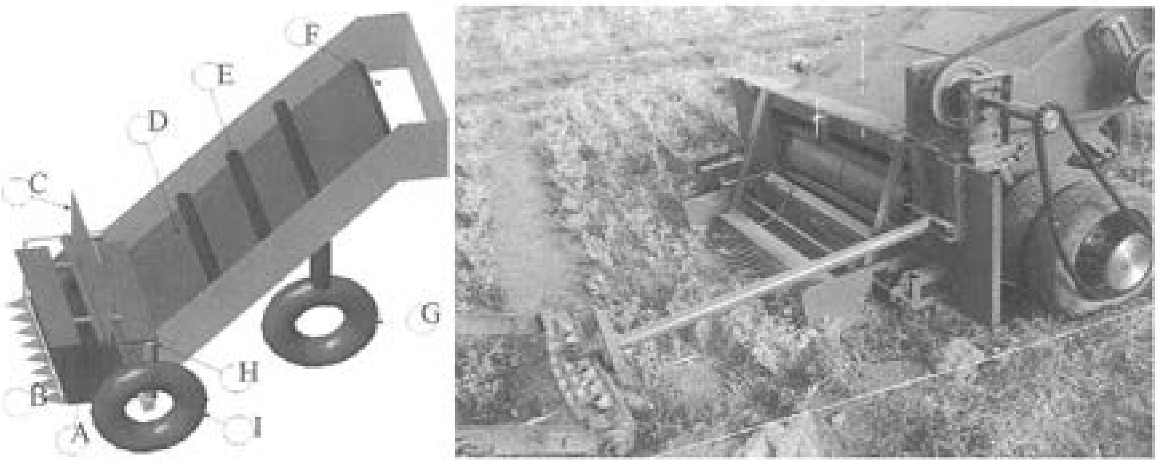
Riethmuller and Pritchard (2003) studied different mechanisms for successful harvesting of peas. They compared the harvesting efficiency of simple pea crop lifters and a plucker front. The belt pick-up had 28 kg/ha average seed loss and crop lifters had 82 kg/ha averaged loss for 1.2 tonn/ha crop. Heaslip pea lifters, Knuckey belt pick-up and tine plucker were used for harvesting of pea. These three harvesting fronts were compared. Tine plucker had highest fronts losses than remaining two. Belt pick-up had least front losses. It was concluded that belt pick up is suitable for harvesting of pea for best economic returns.

Veerangouda *et al* (2010) examined performance evaluation of tractor operated combine harvester as per RNAM and BIS test codes in the fields. They observed that the average value of actual field capacity of the machine was 0.64 to 0.81ha/h with field efficiency of 67.02 to 76.83 percent. The losses were in the range of 2.88 to 3.60 percent for cereals harvesting. The cost of harvesting was less for tractor operated combine harvester as compared to manual harvesting by 57.65 to 65.55 percent.

Alizadeh and Allameh (2013) examined field performance of different harvesting methods and concluded that the maximum and minimum actual field capacity were for whole-crop combine (0.361ha/h) and hand cutting (0.009ha/h) respectively. Total losses were 5.07% for reaper + threshing by universal combine harvester provided with pick up type header (maximum) and 2.74% for head-feed cereal combine (minimum).

Findura *et al* (2013) found that operating at a lesser speed (2.2 km/h), a greater level of entire grains was accomplished. The maximizing of working velocity (vp) to 2.9 km/h caused maximized nearness of harmed peas by 1.2%, compressed peas by 1.22% and the content of trash was increased by 1.88%. They discovered that the major percentages of losses were caused by torn pea pods, which drop on ground and the conveyor was not able to pick them. The mean stalk length was 885 mm and the mean height of matured crop was 464 mm, the grain output obtained 6.28 t/ha and straw output was 20.33 t/ha. The increment in working velocity from 2.2 to 2.9 km/h raises the harm to the grain from 13 to 15.6%. A similar rising pattern was observed in the trash content in the storage tank of the gatherer; the increment of ground speed from 2.2 km/h to 2.9 km/h caused increase in harvesting losses.

Golpira *et al* (2013) made an effort at design and advancement of a chickpea stripper collector. A tractor-pulled harvester with a changed stripper header was composed and developed, in which fingers with V-molded openings expels chickpea pods from standing plant; batted reel clears the pods over the stage. Field tests were carried out to decide the impact of space width and reel speed on working of machine regarding gathering losses. Less damage was observed when the outline was designed with an opening width of 4 cm, reel speed of 50 rpm and reel kinematic index of 1.6. The harvester with a 1 m working width gives the field capacity of 0.18 ha/h and showed adequate working quality. The fundamental conclusion is that the improved stripper header can work in unevenness ground where different machines can't work. The developed machine is shown in Fig.1.



(a) (b)

Figure 1. (a) 3-D model of a prototype chickpea harvester. A, platform; B, finger; C, reel; D, conveyor bottom; E, endless chain; F, sacker unit; G, steering wheel; H, adjustable screw; I, gauge wheel. (b) Tractor-pulled for chickpea stripper harvester.

Lliev *et al* (2016) studied influence of the measurements of lifting brushes on the damage obtained at collecting of standing vine dry bean. According to the height of new cultivars, the space position was determined. It was seen that use of the brushes could diminish the damage at direct collecting under 12%. The round and hollow brushes were provided on the cutter-bar bar along the course of movement of the machine. The width and the longitude of the brushes were examined and the separation between them on the cutterbar. Difficulties during cutting were observed. A brushes size of Ø38, a longitude, equivalent to the longitude of the fingers of the cutter-bar, and a separation of 76.2 mm between brushes were found as ideal. The deposition of the lifting brush is shown in Fig.2.

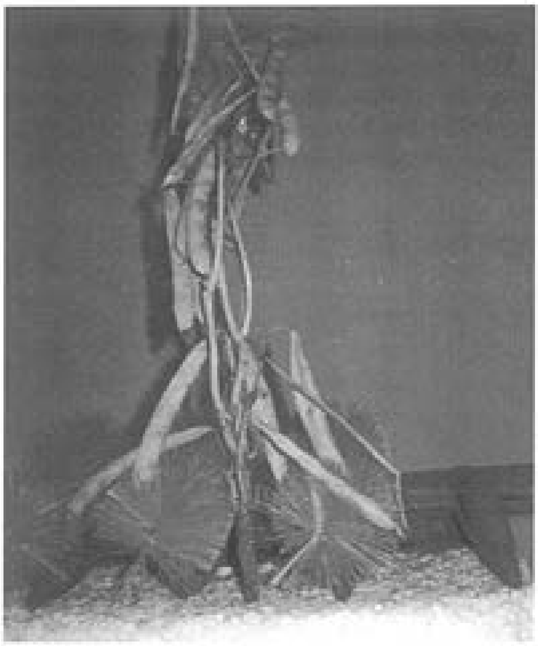


Figure 2. Disposition of the lifting brushes, d=60 mm, l=150 mm, L=76,2 mm

Bieniek *et al* (2017) studied operation of the separation system of NH CR9080 combine harvester. The operational parameters of this machine were evaluated on four fields which differed significantly from each other. The average of losses on sieves was within 3.22% to 3.96% range. Losses on rotors were found to be from 0.02% to 0.05%. The rpm of a fan was changing during operation of the machine within 550-600 rpm range. This change in rotational speed of the fan was due to Opti Fan system which automatically controls the rotational speed of a fan. The rpm of rotors and forward speed of a combine harvester were significant factors which influenced the losses on the screens. The mean rpm of rotors was approx. 580. The optimal forward speed was controlled by an operator. The maximum forward speed was 11 km/h. The rpm of rotors, forward speed of machine and rotational speed of the combine engine had a significant effect on the losses on screens.

3. Harvesting losses of harvester

Glancey *et al* (1996) studied field losses for mechanically harvested green peas pod stripper combines. To assess the efficiency of these machines for pea pod picking in an extensive variety of field conditions, a two-year examination comprising of seventy-one field tests was carried out. The waste content in the collected product varied from 4 to 33.7% by weight with a mean of 15.2%. The total field loss varied from 24 to 1408 kg/ha, resulting in average of 555kg/ha for all the tests in two-year trial. The major part of field losses for the seven varieties and four harvester machines assessed was at the header of the combine averaging 70.3% of the aggregate field losses.

Glancey *et al* (1997) studied header loss from pod stripper combines in green peas. The improvement in pod stripper combine had given a practical technique of successful harvesting of many vegetables. Past examinations on the performance characteristics of pod stripper combine in green peas and lima beans resulted in high field loss, averaging more than 10 and 20% of yield, respectively for every combine made in the USA. Results for the each crop showed that over 75% of the field loss was observed at the header of pod stripper combine. Results show that header problem could be reduced at a combination of forward speed and picking reel speed of 2.2km/h and 205 rpm, respectively.

Hussein and Saadat (2013) compared cutter and feeder mechanism, traditionally hand pulling and combine method on chickpea harvest at different moisture contents. Chickpea plants in Middle East are dwarf and mostly grown on rough dry lands. Chickpea harvesting was evaluated in different harvesting methods; conventional combine, feeder and cutter mechanism harvester and hand pulling method on grain losses. The effect of moisture content was observed at 14%, 11% and 8% (wb) using a split plot experimental design. At final experiment, the popular chickpea variety in Iran ("Flip 93- 255C") was studied and compared with "Hashem" variety. The method of harvesting and moisture content had significant effect on grain losses (P<0.01). On decreasing the moisture content from 14% to 8% (wb) increases the grain loss in all treatments.

Junsiri and Chinsuwan (2009) studied predicted header losses of a combine harvester. The grain moisture content (M), stem length (H), reel index (RI), cutter bar speed (V), tine spacing (R), tine clearance over cutter bar (C), service life of cutter bar (Y), product of M and V, product of RI and R, product of M and Y, product of V and C, V2 and RI2 and product of V and H were significant. The equations had R2 = 0.75. The percentage header losses given by the estimation equation was different from the measurement by only 0.25.

Conclusion

As the area under green pea cultivation is rigorously increasing every year, mechanical harvesting of green pea pods is required. The mechanisation of harvesting of green peas will save the time and energy input of green pea cultivators. As pea pod picking is laborious work, mechanization will reduce the drudgery of the farmers.

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Effect of Botanicals on Number of Egg Laid by *Callosobruchus chinensis* in Stored Chickpea

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Abstract: An experiment was conducted to test the efficacy of botanicals against pulse beetle in stored chickpea. Eight treatment including untreated control comprising of Cinnamon powder (3 g/kg), Clove powder(3 g/kg), Black pepper seed powder(3 g/kg), Turmeric rhizome powder(5 g/kg), Acorus calamus rhizome (Vekhand) powder (2 g/kg), Acorus calamus rhizome (Vekhand) powder(4 g/kg), Acorus calamus rhizome (Vekhand) powder (8 g/kg) were used against adult pulse beetle , Callosobruchus chinensis on chickpea grains. All botanicals recorded minimum eggs laid by the pulse beetles on the grain treated with than the untreated control. Acorus calamus rhizome (Vekhand) powder (8 g/kg) and Acorus calamus rhizome (Vekhand) powder (4 g/kg) were found most effective in inhibiting egg laying even up to 6 month of storage after release of insect.

Keywords : Pulse beetle, botanicals, stored chickpea.

Introduction

In India, Maharashtra is the largest producer of chickpea accounting 14.00% of the total production followed by Madhya Pradesh (39 %). Chickpea is the most important pulse crops after dry bean and peas (Anonymous 2017). Heavy qualitative and quantitative losses occur due to the attack of pulse beetle (*Callosobruchus chinensis)* L. In the stored chickpea grains and other stored grains such as beans, gram and lentil seeds in the developing countries. Invasion of this insect causes reduction in germination of grains , weight loss and lower market value (Raja and William,2008; Patel,2011; Sagheer *et al*., 2013; Islam *et al*., 2013 and Tefsu and Emana, 2013). Numerous control methods have been used for the control of *C. Chinensis* including the use of larval parasitoids as biological control agent, changes in the temperature of storage house and microwave energy use.

India has achieved a record of chickpea with area, production, productivity of 3.55 million ha, and 7.17 million tones respectively (Anonymous 2017). In india there are about 200 species of pest insects which cause damage to stored grains and grains products in storage. *Callosobruchus chinensis* is a major, economically important pest of all pulses and cause 40-50% losses of pulses in storage (Ghosh *et al.*, 2003). However India imports pulses to feed the ever increasing population. Marginal increase in production in the last 4 decades and astronomical losses during post-harvest storage, attributable to the pulse beetle (PB) *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae) (Mendki *et al.*, 1999), are other possible reasons for importing pulses.

Success achieved so far in making the stored products free from pests has been largely dependent on pesticides alone. Pesticides are the most powerful tool available for pest control. Despite these credentials, the long and indiscriminate use of pesticides has been found ecologically unsound. Insecticides were found to cause toxic effects on the produce intended for consumption, which forced a processor to look towards plants and plant products as protectants for stored products as an alternative to the highly persistent synthetic chemicals. Global warming has cautioned us and the adverse consequences (Priyanka *et.al.*,2014). Insecticide use are always alarming and also inducing pest out break because of pest resistance. In this condition, alternative methods of insect control utilizing botanical products are being used in many countries.

There is a need to find some alternative procedure for the control of *C.chinensis*. These methods should be cheaper, safe to environment and human health and highly effective in use an alternative method found is the use of plant part and their products as repellent and deterrents such as essential latex and powders of some parts of plants (Sagheer *et al*.,2013; Khan *et al*.,2014 and Hasan *et al.*,2014). Plant-derived materials are more readily biodegradable, relatively specific in the mode of action and easy to use (Das, 1986); they are environmentally safe, less hazardous, less expensive and readily available. These grain protectants are environmentally safe, less hazardous, less expensive and readily available. Keeping these view in mind, the present experiment is designed to investigate the efficacy of herbal powders against pulse beetle in stored chickpea.

Material and Method

A Laboratory experiment was conducted on "Efficacy of herbal powder against pulse beetle (*Callosobruchus* spp.) in stored chickpea" at the laboratory of AICRP on PHET and Seed Technology Research Unit (STRU), Dr. P.D.K.V. Akola (M.S) under laboratory conditions lasting for a period of 180 days during year 2017-18.

Rearing of test Insect in the laboratory : To obtain adequate culture of *Callosobruchus chinensis* the adults were collected from the Pulses Research Unit, Dr. PDKV, Akola along with pulses chickpea on which eggs were laid by pulse beetle and released into plastic container contains healthy chickpea grains. The top was covered with muslin cloth secured firmly by rubber band. After emergence of new adults, the beetles were introduced in to chickpea variety JAKI-9218. Some adults were transferred into another set of containers containing fresh chickpea grain and such procedure was repeated to maintain the culture throughout the period of research. These cultures were grown in laboratory under ambient conditions . Mass culture of *C. chinensis* was maintained in the laboratory for experimental purpose. One kg of freshly harvested certified grain with very high percentage of germination and low moisture content (<10%) was taken for each replication of all the treatments. This one kg of grain were treated with the botanical powder as per dose given in table number 1. From this 1 kg of already treated grain 100 g was taken out in the plastic container of 250 ml capacity and in which five pairs of adult bruchids (newly emerged) were released to record the observation every month. The observation were recorded at monthly interval on number of egg laying. After 14 days of release of insects, the plastic container of 250 ml capacity were observed and eggs laid on grains were recorded.

Result and Discussion

Effect of botanicals on the number of egg laid by *Callosobruchus chinensis* after 14 days of release

The data shown in table 1 indicated significant difference in respect of number of eggs/100 g seed in all the storage periods after treatment. Numbers of eggs laid/100g seed by the pulse beetles were recorded and data were statistically analysed.

In 1st month

All the treatments were found statistically superior over control and proved effective in bringing about significantly lower egg laying of pulse beetle as compared to untreated control(266.67 eggs/100 g grain). Significantly minimum number of eggs were laid by the beetles in the grains treated with *Acorus calamus* rhizome powder @ 8 g/kg grain(14.00 eggs/100 g grain), which was found to be statistically superior over the rest of treatments.The next best treatment in respect of decreasing efficacy were *Acorus calamus* rhizome powder @ 4 g/kg grain (18.67 eggs/100 g grain) and *Acorus calamus* rhizome powder @ 2 g/kg grain (20.67 eggs/100g grain). Significantly which were found at par with other. The next effective treatment in respect of minimum egg laying was black pepper seed powder 3 g/kg grain (26.33 eggs/100 g grain), clove powder @ 3 g/kg grain (26.67 eggs/100 g grain), cinnamon powder @ 3 g/kg grain (30.33 eggs/100 g grain) and turmeric rhizome powder @ 5 g/kg grain (34.00 eggs/100 g grain). However, these treatments found at par with each other.

In 2nd month

All the treatments were found to be effective in inhibiting the egg laying of pulse beetle on the chickpea grains. Significantly least number of eggs/100 g grain was recoreded on the grains treated with *Acorus calamus* rhizome powder @ 8 g/kg grain (18.00 eggs/100 g grain), which was found superior over the next best treatment, *Acorus calamus* rhizome powder @ 4 g/kg grain (22.67 eggs/100 g grain). The effective treatments in respect of inhibiting the eggs was *Acorus calamus* rhizome powder @ 2 g/kg grain (28.00 eggs/100g grain) and black pepper seed powder @ 3 g/kg grain (33.00 eggs/100 g grain), which were found at par with other. Black pepper powder found at par with next best treatment clove powder @ 3g/kg grain (38.00 eggs/100g grain) followed by cinnamon powder @ 3 g/kg grain (46.67 eggs/100 g grain) and turmeric rhizome powder @ 5 g/kg grain (47.33 eggs/100 g grain). Significantly maximum number of egg were laid in untreated control (281.67 eggs/100 g grain).

In 3rd month

The result presented in table 1 indicated that significantly minimum eggs laying were recorded in *Acorus calamus* rhizome powder @ 8 g/kg grain (25.67 eggs/100 g grain), which was found significantly superior over the rest of treatments. The next effective treatments in respect of inhibiting eggs was *Acorus calamus* rhizome powder @ 4 g/kg grain (31.67 eggs/100 g grain) and *Acorus calamus* rhizome powder @ 8 g/kg grain (37 eggs/100 g grain), which were found statistically at par with the next treatment black pepper seed powder @ 3 g/kg grain (45.67), which was also found at par with next best treatment clove powder @ 3 g/kg grain (47.33 eggs/100g grain) and followed by cinnamon powder @3 g/kg grain (58.67 eggs/100 g grain) and turmeric rhizome powder @ 5 g/kg grain (59.33). Significantly maximum number of eggs was laid in untreated control (308.33 eggs/100 g grain).

In 4th month

All treatments were found effective in inhibiting the egg laying of pulse beetles on the stored chickpea grain. Significantly minimum eggs laid by the pulse beetles on the grain treated with *Acorus calamus* rhizome powder @ 8 g/kg grain (29.33 eggs/100 g grain), which was found significantly superior over the rest of treatment and followed by *Acorus calamus* rhizome powder @ 4 g/kg grain (35.67 eggs/100 g grain) and *Acorus calamus* rhizome powder @ 2 g/kg grain (44 eggs/100 g grain). The next best treatment in respect of egg inhibiting was black pepper powder @ 3 g/kg grain (55.67 eggs/100 g grain). Black pepper seed powder was found at par with next best treatment clove powder @ 3 g/kg seed (58.33 eggs/100 g seed). Clove powder was also found at par with next best treatment cinnamon powder @ 3 g/kg grain (65.33 eggs/100 g grain) followed by turmeric rhizome powder @ 5 g/kg grain (72.33 eggs/100 g grain). Significantly maximum number of eggs was laid in untreated control (333.67 eggs/100 g grain).

In 5th month

At fifth month after treatment, all the treatments were found statistically superior over untreated control (356.00 eggs/100 g grain) in respect of minimizing eggs laying of pulse beetle. Significantly least number of eggs was recorded on the grains treated with *Acorus calamus* rhizome powder @ 8 g/kg grain(41.00 eggs/100 g grain) followed by *Acorus calamus* rhizome powder @ 4 g/kg grain (49.00 eggs/100 g grain) and *Acorus calamus* rhizome powder @ 2 g/kg grain (56.33 eggs/100g grain). The next effective treatments were black pepper seed powder 3 g/kg grain (68.67 eggs/100 g grain) and clove powder @ 3 g/kg grain (72.33 eggs/100 g grain),which were found at par with each other. Clove powder treatment also found at par with next best treatment cinnamon powder @ 3 g/kg grain (79.67 eggs/100 g grain) and turmeric rhizome powder @ 5 g/kg grain (86.67 eggs/100 g grain). These two treatments which were found at par with each other.

In 6th month

The result showed in Table 1 indicated that all treatments were found significantly superior over untreated control in minimizing the number of eggs laying by pulse beetle. Statistically minimum egg laying was observed on the seeds treated with *Acorus calamus* rhizome powder @ 8 g/kg grain (45.00 eggs/100 g grain). The next best treatment was *Acorus calamus* rhizome powder @ 4 g/kg grain (56.00 eggs/100 g grain) followed by *Acorus calamus* rhizome powder @ 2 g/kg grain (64.33 eggs/100g grain) and black pepper seed powder 3 g/kg grain (70.33 eggs/100 g grain). The remaining treatment in order of decreasing efficacy in terms of minimizing egg laying of pulse beetle were clove powder @ 3 g/kg grain (75.67 eggs/100 g grain), cinnamon powder @ 3 g/kg grain (81.67 eggs/100 g grain) and turmeric rhizome powder @ 5 g/kg grain (88.33 eggs/100 g grain). Significantly maximum number of eggs was laid in untreated control (380.67 eggs/100 g grain).

Table 1: Effect of botanicals on egg laying of *Callosobruchus chinensis* (L.) on stored Chickpea Grains

Sr. No.	Treatments	Doses g /kg seed	Average no. of egg laid after 14 days of beetles release/ 100 gm grains						
			In 1st month	In 2nd month	In 3rd month	In 4th month	In 5th month	In 6th Month	Cumulative mean
1	Cinnamon powder	3 g	26.33 (1.42)	38.00 (1.58)	45.67 (1.66)	58.33 (1.77)	79.67 (1.90)	81.67 (1.91)	54.94 (1.70)
2	Clove powder	3 g	30.33 (1.48)	46.67 (1.67)	58.67 (1.77)	65.33 (1.81)	72.33 (1.86)	75.67 (1.88)	58.16 (1.74)
3	Black pepper seed powder	3 g	26.67 (1.43)	33.00 (1.52)	47.33 (1.67)	56.67 (1.75)	68.67 (1.84)	70.33 (1.85)	50.44 1.67)
4	Turmeric rhizome powder	5 g	34.00 (1.53)	47.33 (1.67)	59.33 (1.77)	72.33 (1.86)	86.67 (1.94)	88.33 (1.95)	64.66 (1.78)
5	*Acorus calamus* rhizome powder	2 g	20.67 (1.31)	28.00 (1.44)	37.00 (1.57)	44.00 (1.64)	56.33 (1.75)	64.33 (1.81)	41.72 (1.58)
6	*Acorus calamus* rhizome powder	4 g	18.67 (1.27)	22.67 (1.35)	31.67 (1.50)	35.67 (1.55)	49.00 (1.69)	56.00 (1.75)	35.61 (1.51)
7	*Acorus calamus* rhizome powder	8 g	14.00 (1.14)	18.00 (1.25)	25.67 (1.41)	29.33 (1.47)	41.00 (1.61)	45.00 (1.65)	28.83 (1.42)
8	Untreated / control	-	266.67 (2.42)	281.67 (2.45)	308.33 (2.49)	333.67 (2.52)	356.00 (2.55)	380.67 (2.58)	321.66 (2.50)
	F' test		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	
	SE(m) ±		0.03	0.03	0.03	0.02	0.02	0.01	
	CD at 5 %		0.10	0.09	0.08	0.05	0.05	0.03	
	CV		3.99	3.24	2.57	1.66	1.48	0.80	

Figures in parenthesis are corresponding logarithmic transformation value

Discussion

From the experimental finding, it was noticed that the average number of eggs laid / 100 g seed recorded after 14 days after introduction of adult beetles, varied significantly in all the storage periods after botanicals treatments.

Significantly minimum number of eggs were laid by the beetles in the grains treated with *Acorus calamus* rhizome powder @ 8 g/kg grain(14.00 eggs/100 g grain) followed by *Acorus calamus* rhizome powder @ 4 g/kg grain (18.67 eggs/100 g grain), *Acorus calamus* rhizome powder @ 2 g/kg grain (20.67 eggs/100g grain), black pepper seed powder 3 g/kg grain (26.33 eggs/100 g grain), clove powder @ 3 g/kg grain (26.67 eggs/100 g grain), cinnamon powder @ 3 g/kg grain (30.33 eggs/100 g grain) and turmeric rhizome powder @ 5 g/kg grain (34.00 eggs/100 g grain) and in untreated control (266.67 eggs/100 g grain) in first month. While after 6 months, cumulative mean of average no. of egg laid (of entire six months data) was derived and it was found that similar order of effectiveness of botanicals on average no. of egg laid by pulse beetle even after six months.

These findings derive support from Shivanna *et al.* (1994) who reported effectiveness of sweet flag at all dosage levels (0.5, 1.5, 2.5 g/ 50g of grain) reduced the egg laying considerably. The average fecundity in sweet flag treated seed ranged from 5-8 eggs and tulsi treated seed at all 3 dosage levels (0.5, 1.5, 2.5 g/ 50g seed) has recorded maximum number of eggs(200) which were on par with untreated check.

Meghwal *et al.* (2012) also reported minimum (6 to 8 eggs/100 g seed) egg laying of pulse beetle due to *Acorus calamus* rhizome powder @ 10 g/kg seed was most effective in respect of inhibiting the eggs laying.

Saiful *et al.* (2013) who also found that black pepper powder @ 5 g/kg seed were found most effective in checking egg laying

Conclusion

Acorus calamus rhizome powder @ 8 g/kg grain and *Acorus calamus* rhizome powder @ 4 g/kg grain recorded most effective in respect of inhibiting the eggs laying of pulse beetle and can used for successful protection of chickpea grain up to six months of storage.

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Effect of Plant Products on Infestation of Callosobruchus spp. on Stored Chickpea

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Abstract : An experiment conducted on the "Effect of plant products on infestation of Callosobruchus spp. on stored chickpea" at Entomlogy Section, College of Agriculture, Nagpur during 2019-2020 smearing with seven plant products i.e. Neem oil + Castor oil, Sesame oil + Groundnut oil + Mustard oil, Neem oil, Castor oil, Sesame oil, Groundnut oil, Mustard oil @ 5 ml/kg seeds tested under laboratory condition each up to 180 days of storage against Callosobruchus chinensis L. infesting stored chickpea seeds. The observation on 100 seeds at 30, 60, 90, 120, 150, 180 days on oviposition, Adult emergence, per cent seed damage was observed due to infestation of Callosobruchus chinensis L. on chickpea. The rate of oviposition there was significant effect among all plant products treatments. The lowest rate of oviposition was observed in neem oil + castor oil (1.33 eggs) and found superior to all other treatments, while the highest rate of oviposition was recorded in untreated control (225.33 eggs) treatment and the order of effectiveness among the treatment was neem oil, castor oil, sesame oil + groundnut oil + mustard oil, mustard oil, groundnut oil and sesame oil. However mustard oil (44.66 eggs) found statistically at par with groundnut oil (45.66 eggs). There was significant effect among all treatments and adult emergence increase with increase in storage period except neem oil + castor oil found no number of adult emergence after 120 days of treatment. The next effective treatment were found neem oil and castor oil with 9.66 and 17.66 adults/100 seeds. Among plant products groundnut oil (48.33 adults) and sesame oil (51.66 adults) found less effective treatments. However mustard oil found statistically at par with groundnut oil and sesame oil. The untreated control (124.33 adults) recorded highest number of adult emergence compared to all treatments. Significantly lowest per cent seed damage observed in the seed treated with neem oil + castor oil (0.00 %) and found statistically superior over all the treatment. The next effective treatment were found neem oil and castor oil with 8.00 and 22.33 per cent seed damage respectively. However, musrard (36.33 %) oil followed by groundnut oil (43.00 %). The untreated control recorded highest per cent seed damage (97.00 %).

Key words : Pulse beetle, botanicals, stored chickpea, seed treatment

Introduction

Callosobruchus chinensis linn. (Coleoptera: Bruchidae) is one of the destructive pest of stored pulse in India. Chickpea is attacked by various insect pest particularly the *Callosobruchus chinensis* L. often resulting in alarming quantitative losses. *Callosobruchus chinensis* L. Being internal feeders, derive their food from cotyledon and lead to gradual loss of the seeds. Generally, the pesticides are used for the control of insect pest but due to their several drawbacks, researchers are trying to adopt alternative method of pest control (Mahmud et al. 2002). The use of locally available Indigenous plant materials were used in ancient technology and for the control of pest in many parts of the world (Roy et al. 2005). The pest efficacy of many plant derivatives has already been proved against several storage pests (Rehman and Talukdar 2006; Mahadi and Rehman 2008). These are also having less environmental impact in terms of insecticidal hazards and could benefit our agriculture sector. Besides, these botanical pesticides are cheaper, easy to process and raw materials are available at village level.

Seed treatment with insecticides to protect the pulse beetle is one of the method and the toxic chemicals evidently have posed serious problems like chronic and acute toxicity,residual toxicity hazards and development of resistance in insect. Out of many methods used for preparation and control of stored grain pests, the use of vegetableoil as grain protectant has many advantages over insecticides as they do not have mammalian toxicity and health hazards, Less expensive, easily available, easy in handling under the stored conditions. Therefore, the present study is carried out to evaluate the study of *"Effect of plant products on infestation of Callosobruchus spp. on stored chickpea"* " under laboratory condition.

In present research work, different seed protectants such as neem + castor oil, sesame + groundnut + mustard oil, neem oil, castor oil,sesame oil,groundnut oil, mustard oil were evaluated for their efficacy against pulse beetles. Keeping this in view, the experimentwere designed with objectives to study the efficacy of plant products against *Callosobruchus spp.*onchickpea seed

Materials and Methods

The present investigation were carried out with 8 treatment replicated thrice in complete randomised design in the Biocontrol Laboratory, Entomology Section, College of Agriculture, Nagpur, Maharashtra during August to February of 2019-20. The rearing of host insect *Callosobruchus chinensis* L. was done under control room temperature and relative humidity condition ranging from 20-30^{0}c and 80-90 per cent.

Chickpea seed variety JAKI-9218 were obtained from the storage godown of farmer. The seed was cleaned and sieved with 10/64 - inch (3.96 mm) diameter sieve to remove small fraction of seed or insect produced in 2018-2019. The seed were cleaned and dried (moisture content 9.88 %). The initial infested seed of chickpea culture was reared in the laboratory to obtain the new culture of *Callosobruchus chinensis* on chickpea. Chickpea seed was treated with eight plant products viz., edible oil (Sesame oil + Mustard oil + Groundnut oil), Non edible oil (Neem oil + Castor oil), Sesame oil, Groundnut oil, Mustard oil, Castor oil and Neem oil is in proportion of 5 ml/500 gm seed. The experiment was conducted in glass bottle of 1 kg capacity with eight treatment including untreated control. Each glass bottle was filled with 500 gm of seed. 10 pair of 2 to 3 days old *Callosobruchus chinensis* were released in each glass bottle and was covered with muslin cloth. The culture of pulse beetles was raised by collecting adults from the infested chickpea seeds from farmer storage seeds. The new culture was maintained in big glass jar containing chickpea seeds. The mouth of the container was covered by muslin cloth fastened with rubber bands. Fresh seeds were provided periodically for the development of beetles. The culture so maintained was used throughout period of investigation.

Seed treatment with plant products

Chickpea seed was treated with eight plant products viz., Non edible oil (Neem oil + Castor oil), edible oil (sesame oil + Mustard oil + Groundnut oil), Neem oil, Castor oil, Sesame oil, Groundnut oil and Mustard oil is in proportion of 5 ml/500 gm seed. Similarly control without treatment of seed protectants was kept for comparison. The experiment was conducted in glass bottle of 1 kg capacity with eight treatment including untreated control. Each treatment was replicated thrice by following CRD.

Artificial infestation of pulse beetle

After application of the seed treatments with different plant products, the seeds were filled in glass bottle. Likewise, a separate lot of untreated seeds were maintained. Ten pairs of freshly emerged pulse beetle (*Callosobruchus chinensis* L.) were released in each of the above glass bottle with the help of brush and then covered by muslin clothes and fastened with rubber bands. All Observation on various parameter were recorded on 30,60, 90,120,150and 180 days of treatment. The 100 grains of seed samples were drawn from each treatment and number of eggs laid on these seeds were recorded and data were statistically analyzed. The 100 seed samples were drawn from each treatment and number of seeds with exit holes (adult emergence) was counted and counted data were statistical analysis. The 100 grains of seed from each treatment was selected randomly after the emergence of adult and damaged seeds were counted. From this, percentage of damaged seeds was worked out by using the following formula:

$$\text{Percent grain damged} = \frac{\text{Number of holed seeds}}{\text{Totalnumber of seeds}} \times 100$$

Result and Discussion

Effect of Plant products on oviposition of *Callosobruchus chinensis* L. on chickpea seeds

The data on average number of eggs laid by *Callosobruchus chinensis* L. on 100 seed of chickpea treated with different plant products are presented in table 2. A significant variation was observed among different treatments in terms of the effect of different plant oils @ 5 ml/kg seeds on number of eggs laid by *Callosobruchus chinensis* L. at different storage periods starting from 30 to 180 days after treatment considering 30 days interval during management of pulse beetle on chickpea. The seed treatment with neem oil + castor oil was found to be most effective throughout the storage period of 180 days, whereas groundnut oil and sesame oil were found to be less effective against *Callosobruchuschinensis* L.

Considering the rate of oviposition there was significant effect among all plant products treatments. The lowest rate of oviposition was observed in neem oil + castor oil (1.33 eggs) and found superior to all other treatments, while the highest rate of oviposition was recorded in untreated control (225.33 eggs) treatment and the order of effectiveness among the treatment was neem oil, castor oil, sesame oil + groundnut oil + mustard oil, mustard oil, groundnut oil and sesame oil. However mustard oil (44.66 eggs) found statistically at par with groundnut oil (45.66 eggs). The superiority of neem oil + castor oil over the other plant oil tested in the present study was in agreement with the results about the effectiveness of neem oil by Tripathi et al. (2006) showed significantly repellent action for eggs laying by pulse beetle upto 90 days after treatment of neem oil at 1.00 per cent. The similar result observed by N. Rajasri and P. Sambasiva Rao (2012) observed and reported significant repellent action of neem oil against egg laid by adult of *C. chinensis* for upto 100 days after treatment on pigeonpea storage and Srinivasan (2008) also reported that mean number of egg laid per 100 seeds was least in 5 and 10 ml neem oil after 6 months of treatment.

Table 2. Effect of plant products on oviposition of *Callosobruchus chinensis* L. on chickpea seed

Sr. No.	Treatment	Dose ml/kg seed	Mean number of eggs laid per 100 seed at					
			30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T1	Neem oil + castor oil	5 ml	1.66 (1.27)	3.33 (1.79)	6.00 (2.44)	3.33 (1.79)	2.00 (1.38)	1.33 (1.13)
T2	Sesame oil + Mustard oil + Groundnut oil	5 ml	6.66 (2.57)	16.66 (4.08)	26.33 (5.12)	28.00 (5.29)	32.66 (5.72)	39.33 (6.21)
T3	Neem oil	5 ml	2.33 (1.52)	5.00 (2.23)	8.66 (2.93)	12.33 (3.51)	14.66 (3.82)	15.66 (4.16)
T4	Castor oil	5 ml	4.00 (1.99)	9.00 (2.99)	16.66 (4.07)	23.00 (4.79)	25.66 (5.06)	31.00 (5.56)
T5	Sesame oil	5 ml	17.66 (4.19)	22.66 (4.74)	38.66 (6.21)	42.33 (6.50)	48.66 (6.97)	56.00 (7.48)
T6	Groundnut oil	5 ml	14.33 (3.77)	20.00 (4.47)	33.00 (5.74)	37.33 (6.10)	40.66 (6.37)	45.66 (6.75)
T7	Mustard oil	5 ml	8.33 (2.88)	17.33 (4.16)	30.33 (5.51)	34.33 (5.86)	36.00 (5.99)	44.66 (6.68)
T8	Control (untreated)	-	31.00 (5.56)	68.00 (8.24)	92.66 (9.63)	128.33 (11.33)	152.66 (12.20)	225.33 (15.16)
	'F' TEST		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) +		0.18	0.17	0.22	0.14	0.15	0.13
	CD at 5%		0.53	0.51	0.45	0.40	0.43	0.38

(Figure in parentheses are transformed square root value)

Effect of plant products on adult emergence of *Callosobruchus chinensis* L. on chickpea seeds.

The data presented in table 3. indicate that all the treatments with different seed protectants resulted in reduced adult emergence of *Callosobruchus chinensis* L. as compared to untreated control. Significant variations were observed among different treatments in term of adult emergence throughout the storage period of 180 days. Neem oil + castor oil found superior over all the treatment throughout the storage period in reducing adult emergence, whereas groundnut oil and sesame oil found inferior among all plant products in respect of adult emergence.

Considering the adult emergence (Table 3) there was significant effect among all treatments and adult emergence increase with increase in storage period except neem oil + castor oil found no number of adult emergence after 120 days of treatment. The next effective treatment were found neem oil and castor oil with 9.66 and 17.66 adults/100 seeds. Among plant products groundnut oil (48.33 adults) and sesame oil (51.66 adults) found less effective treatments. However mustard oil found statistically at par with groundnut oil and sesame oil. The untreated control (124.33 adults) recorded highest number of adult emergence compared to all treatments.

Table 3: Effect of plant products on adult emergence of *Callosobruchus chinensis* L. on chickpea seed

Sr. No.	Treatment	Dose ml/kg seeds	Mean no of adult emergence per 100 seed at					
			30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T1	Neem oil + castor oil	5 ml	0.00 (0.71)	1.33 (1.14)	2.00 (1.38)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T2	Sesame oil + mustard oil + groundnutoil	5 ml	1.33 (1.14)	3.33 (1.79)	9.66 (3.10)	17.66 (4.19)	26.66 (5.16)	35.33 (5.94)
T3	Neem oil	5 ml	0.00 (0.71)	2.00 (1.38)	4.00 (1.99)	5.33 (2.27)	7.66 (2.76)	9.66 (3.10)

T4	Castor oil	5 ml	1.00 (1.00)	2.67 (1.58)	7.00 (2.64)	10.66 (3.25)	14.66 (3.82)	17.66 (4.20)
T5	Sesame oil	5 ml	6.67 (2.57)	13.00 (3.9)	18.66 (4.06)	32.00 (5.65)	42.66 (6.52)	51.66 (6.95)
T6	Groundnut oil	5 ml	5.00 (2.24)	10.33 (3.21)	16.66 (4.32)	30.66 (5.22)	35.33 (5.93)	48.33 (7.18)
T7	Mustard oil	5 ml	4.33 (2.06)	9.33 (3.05)	14.00 (3.74)	22.00 (4.68)	33.00 (5.74)	46.33 (6.18)
T8	Control (untreated)	-	16.00 (3.99)	36.66 (6.04)	48.33 (6.95)	81.33 (9.02)	97.33 (9.86)	124.33 (11.14)
'F' TEST			Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)+			0.16	0.20	0.16	0.18	0.16	0.14
CD at 5%			0.46	0.61	0.48	0.54	0.48	0.40
(*Figure in parentheses are transformed square root value)								

Similar result about the effectiveness of neem oil against the pulse beetles were observed by Khaire etal. (1992) who reported that neem oil (at 0.5, 0.75 and 1%) prevented adult emergence of *C. chinensis* upto 100 days in pigeon pea treated seed. Thus, result is also in agreement with Miah etal. (2013) reported that no larvae, pupa development of *Callosobruchus maculates* were found in neem oil, castor oil, camphor oil, treated greengram due to toxic effect of these botanicals. This result was also in agreement with Rashmi et al. (2014) reported that among botanicals neem oil @ 5 ml/kg of seed recorded minimum adult emergence of *Callosobruchuschinensis* on stored pigeonpea upto six month of storage. Kumar L.B. et al. (2017) reported that neem oil @ 2.5 ml/kg seed significantly reduced the adult emergence of *C. chinensis* in greengram in comparison with untreated control.

Effect of plant products on per cent seed damage caused by *Callosobruchus chinensis* L.

The data presented in table 4. and graphically in fig. 3 indicate that all treatments with different seed protectants resulted in reduced per cent seed damage caused by *Callosobruchus chinensis* L. as compared to untreated control. Significant variations were also observed among different treatments in term of per cent seed damage throughout the storage period of 180 days.

Table 4 : Effect of plant products on per cent seed damage caused *Callosobruchus chinensis* L. on chickpea seed

Sr. No.	Treatment	Dose ml/kg seeds	Mean per cent seed damage per 100 seed at					
			30 DAT *	60 DAT *	90 DAT * *	120 DAT **	150 DAT **	180 DAT **
T1	Neem oil + castor oil	5 ml	0.00 (0.71)	0.66 (0.90)	1.66 (7.33)	0.00 (3.71)	0.00 (4.17)	0.00 (4.48)
T2	Sesame oil + groundnut oil + mustard oil	5 ml	3.00 (1.71)	7.00 (2.64)	9.33 (17.75)	17.00 (24.34)	21.33 (27.29)	30.00 (33.19)
T3	Neem oil	5 ml	0.00 (0.71)	1.33 (1.14)	3.00 (9.88)	4.33 (11.94)	6.66 (14.89)	8.00 (16.41)
T4	Castor oil	5 ml	0.66 (0.90)	3.00 (1.71)	7.00 (15.24)	12.66 (20.78)	18.00 (25.07)	22.33 (28.19)
T5	Sesame oil	5 ml	7.66 (2.76)	15.66 (3.94)	22.33 (28.14)	30.00 (33.21)	40.33 (39.42)	47.66 (43.66)
T6	Groundnut oil	5 ml	6.66 (2.56)	12.33 (3.50)	15.66 (23.29)	26.33 (30.87)	33.66 (35.80)	43.00 (40.96)
T7	Mustard oil	5 ml	3.33 (1.79)	8.66 (2.93)	13.00 (21.12)	20.33 (26.79)	28.00 (31.93)	36.33 (37.06)
T8	Control (untreated)	-	17.00 (4.12)	26.33 (5.13)	42.00 (40.39)	67.33 (55.18)	88.00 (69.78)	97.00 (80.41)
'F' TEST			Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)+			0.16	0.16	1.08	0.92	0.88	1.17
CD at 5%			0.46	0.47	3.16	2.69	2.56	3.42
(* Figure in parentheses are transformed square root value, ** Figure in parentheses are transformed arcsin value.)								

Considering per cent seed damage observed lowest per cent seed damage in neem oil + castor oil (0.00 %) and found statistically superior over all the treatment. The next effective treatment were found neem oil and castor oil with 8.00 and 22.33 per cent seed damage respectively. However, musrard (36.33 %) oil followed by groundnut oil (43.00 %). The untreated control recorded highest per cent seed damage (97.00 %).

The result on use of neem oil at 10 and 5 ml/kg seeds as seed protectant is corroborated by Srinivasan (2008) who reported highly effective against *Callosobruchus chinensis* registering the minimum seed damage as 9.2 and 15 per cent. Lal and Deepshika (2012) reported grains treated with neem and castor oil preventing 0.55 and 0.46 per cent grain damage by *Callosobruchusmaculates* inpigeonpea seed. The result also in agreement with Bhardwaj and Verma (2013) found that neem oil was most effective treatment which provides significant less seed damage 0.11 per cent in pea seed infested with *Callosobruchus chinensis* L.

Conclusion

The plant based protectant of neem oil + castor oil, sesame oil + groundnut oil + mustard oil, neem oil, castor oil, sesame oil, groundnut oil, mustard oil was found to be significantly effective against *Callosobruchus chinensis* L. infesting chickpea seed during storage in reducing oviposition, adult emergence, per cent seed damage of seeds

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Genetic Variability studies in Sunflower Germplasm

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Abstract: Sunflower (*Helianthus annuus L.*) is the fourth largest seed crop worldwide after the Oil Palm, soybean and rapeseed. The experiment was conducted at Oilseeds Research Unit, Dr. PDKV, Akola during *Kharif* 2019-2020, to study the Genetic Variability studies in Sunflower Germplasm. The experiment consisted of 76 sunflower genotypes of CMS (11), Restoreres (45) and Inbreds (20) lines were evaluated with five checks (CMS 17 B,CMS 850 B, ARM 243B, LTRR 341 and RHA 1-1R) and was laid out in Augumented Block Design. In this study illustrated that, the existence of wide ranges of variations for most of the characters among the sunflower genotypes, which provides opportunity for genetic gain through selection. All the CMS lines except CMS 850B and CMS 2 B found to be significantly superior in seed yield plant-^{1} over the best check CMS 17 B (15.0 g plant-^{1}). However, CMS 138 B line ranked first for seed yield (23.4 g plant-^{1}). AKSF 10-2-2B (39.5 %) and CMS 234 B (39.1 %) lines were found to be good for oil content over the best check ARM 243 B (38.5%).

All the restorer lines except EC 6023025R, EC 601817, EC 602303 and EC 512682 found to be significantly superior in seed yield plant-^{1} over the best check RHA-1-1R (13.7 g plant-^{1}). However the restorer line RHA 138-2R (30.5 g plant-^{1}) ranked first in respect of seed yield-^{1}. Two R lines were found to be significantly superior for oil content as compared to check RHA-1-1R (36.5%). However R line EC 512687 R (38.4 %) and EC 6023072 (37.8%) recorded highest oil content among all R lines.

All the inbred lines except AKSFI 209 and AKSFI 140 found to be significantly superior seed yield plant-^{1} as compared to the check LTRR 341(16.5 g plant-^{1}). However AKSFI 174 (28.5 g plant-^{1}) recorded highest seed yield -^{1} among all the inbreds. For oil content four inbreds found to be significantly superior for oil content than the check LTRR 341 (35.5%). However, oil content was found to be highest in AKSFI 174 (38.5 %). These new CMS lines and corresponding fertility restoration lines will provide cytoplasmic diversity for hybrid sunflower production.

Keywords: Germplasm, Augumented Block Design, CMS lines, Restorer lines and Inbred lines.

Introduction

Sunflower (*Helianthus annuus L.*) is an important oilseed crop, which belongs to the genus 'Helianthus' of the family Asteraceae. It is widely adopted and accepted for its high quality and nutritional edible oil. Due to its high economic importance, the developments of effective hybrids are required with superior yield and quality traits. Presence/existence of ample amount of genetic variability is prerequisite before embarking any breeding programme. Information of variability is useful to formulate selection criteria for improvement of seed yield and its component traits. Hence, variability present in a gene pool of a crop species is important to plant breeder for breeding programme. Classification of germplasm based on agronomic characters plays an important role in plant breeding to select valuable genetic resources to be utilized later in different breeding programmes.

Germplasm collections conserve the genetic diversity within species in addition to providing rare alleles for crop improvement. Augmented block design is used, since large numbers of accessions are evaluated under field conditions. It is essentially important where initially limited seed is available to undertake replicated experiments. This design is also used where comparably homogeneous experimental unit which is a basic requirement of field designs is not ensured. Characterization and evaluation of germplasm accessions are a regular activity carried out by germplasm curator to unravel the variability present among the germplasm and to identify the important trait-specific accessions for breeding programme. In any crop, precise phenotyping at field level not only helps to identify useful genes but also provides a material with specific traits with wider adaptability. In order to execute successful breeding programme, the total variability present in the available germplasm pool is important The collection may help to improve economical traits related to the yield and quality and also supply biotic and abiotic resistance genes. Moreover, the elite germplasm may help to initiate sunflower breeding programs in many countries.

Diversity of sunflower germplasm is usually studied to determine the crop variability and to evaluate the existing germplasm for breeding programme or to detect needed variability for morphological and agronomic traits. Therefore, knowledge of the exiting genetic diversity in the germplasm is essential for undertaking recombination breeding. The analysis of genetic diversity in germplasm collections helps the germplasm curator in classification of accessions and in the identification of core accessions or subsets for utilization in specific breeding programme. Based on morphological, physiological and biochemical data, the genetic diversity of sunflower genotypes was estimated

Materials and Methods

The experiment was conducted at Oilseeds Research Unit, Dr. PDKV, Akola during *Kharif* 2019-2020, to study the Genetic Variability studies in Sunflower Germplasm. The experiment consisted of 76 sunflower genotypes of CMS (11), Restoreres (45) and Inbreds (20) lines were evaluated with five checks (CMS 17 B, CMS 850 B, ARM 243B, LTRR 341 and RHA 1-1R) and was laid out in Augumented Block Design. At maturity five plants from each accession were selected randomly for recording of data on yield and its related characters viz. days to 50% flowering, duration of reproductive phase (days), days to maturity, plant height (cm), head diameter (cm), seed yield (g), 100-seed weight (g), and oil content (%).

Results and Discussion

When a large set of germplasm accessions are to be evaluated to select appropriate genotypes for specific breeding purposes, augmented block design is a most preferred method for initial evaluation. Large number of test entries is evaluated along with standard checks, with the checks being replicated randomly in all blocks. The data from checks are used to adjust mean values of test entries to make them comparable and also to provide an estimate of experimental error. Further, it indicates whether there is sufficient genetic variation present in a population which will respond to selection pressure. Selection of the genotype based on specific character with high broad-sense heritability will lead to faster and increased gains in the offspring than selecting for specific character with low heritability.

In this study illustrated that, the existence of wide ranges of variations for most of the characters among the sunflower genotypes, which provides opportunity for genetic gain through selection. All the CMS lines except CMS 850 B and CMS 2 B found to be significantly superior in seed yield plant-^{1} over the best check CMS 17 B (15.0 g plant-^{1}). However, CMS 138 B line ranked first for seed yield (23.4 g plant-^{1}) and range from 14.95 to 23.55 g plant^{-1}. AKSF 10-2-2B (39.5 %) and CMS 234 B (39.1 %) lines were found to be good for oil content over the best check ARM 243 B (38.5%) and range from 35.42 to 39.50 percent. While days to 50 % flowering range from 50 to 60, Days to maturity 80to 88, plant height 95.2 to 175.2 cm, head diameter 12.2 to 15.0 cm and 100 seed weight 3.6 to 8.5 g respectively (Table 1). These CMS lines and corresponding fertility restoration lines will provide cytoplasmic diversity for hybrid sunflower production Encheva et al. (2008) and Onemli and Gucer (2010) reported significant differences in plant height, head diameter, and period of flowering of sunflower wild genotypes.

All the restorer lines except EC 6023025R, EC 601817, EC 602303 and EC 512682 found to be significantly superior in seed yield plant^{-1} over the best check RHA-1-1R (13.7 g plant-^{1}). However the restorer line RHA 138-2R (30.5 g plant-^{1}) ranked first in respect of seed yield-^{1}. While seed yield range from 13.0 to 30.5 g plant-^{1}. Two R lines were found to be significantly superior for oil content as compared to check RHA-1-1R (36.5%). However R line EC 512687 R (38.4 %) and EC 6023072 (37.8%) recorded highest oil content among all R lines and ranges between 31 to 38.4 percent. However days to 50 percent flowering range from 50 to 59 days, days to maturity 78 to 86 days, plant height ranges 99.54 to 164.86 cm, head diameter 10.5 to 15.0 cm and 100 seed weight 3 to 5.2 g respectively (Table 1).

All the inbred lines except AKSFI 209 and AKSFI 140 found to be significantly superior seed yield plant-^{1} as compared to the check LTRR 341 (16.5 g plant-^{1}). However AKSFI 174 (28.5 g plant-^{1}) recorded highest seed yield^{-1} among all the inbreds and range from 16.5 to 28.5 g plant-^{1}. For oil content four inbreds AKSFR 174 (38.5%), AKSFI 216 (37.20%), AKSFI 218 (36.3%) and AKSFI 217 (36.8 %) found to be significantly superior for oil content than the check LTRR 341 (35.5%). However, oil content was found to be highest in AKSFI 174 (38.5 %) and range from 32.22 to 38.50 percent. While days to 50 percent flowering range from 48 to 62 days, days to maturity 80 to 90 days, plant height 75.5 to 120.5 cm, head diameter 10.2 to 15.5 cm and 100 seed weight 3.2 to 5.8 g respectively (Table 1).

Accessions which have high seed weight and oil content are categorized as potential accessions because seed weight is one of important considerable yield components (Dehkhoda et al. 2013 and Rafiei et al. 2013).

Genetic variation existed among the elite and wild germplasm and introgression of resistant genes was successfully carried out in elite germplasm. Hybrid breeding is used to manipulate heterosis and to increase the grain yield. Development of elite breeding line with superior combining ability is one of the prime breeding objectives of sunflower. In order to expand genetic diversity, cytoplasmic male sterility sources have been expanded which could be used to develop hybrids from novel source of cytoplasmic male sterility and fertility restorer lines. These CMS lines and corresponding fertility restoration lines will provide cytoplasmic diversity for hybrid sunflower production (Dudhe et,al 2019).

Conclusion

While selecting appropriate sunflower germplasm, the breeder looks for genetically diverse and superior genotypes which could be utilized in population and heterosis breeding. The present study exhibited very high differences among the genotypes for seed yield almost all yield component characters which may favour the selection and its further utilization in recombination breeding programmes.

Implications

The genetically diverse sunflower germplasm identified could be utilized in development of diverse inbreds which may be utilized in heterosis breeding. Promising trait specific superior sunflower germplasm accessions identified will serve as donors for the development of trait specific heterotic gene pools which can be further exploited in sunflower improvement, for seed yield, oil content and plant type besides biotic and abiotic resistance under diverse agro ecological situations.

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Table 1 : Evaluation of available CMS, R lines and other promising inbreds lines

SN	Genotype	Seed yield (g/plot)			oil content (%)			DAS 50% flowering		
		UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect
1	CMS 850 B	15.40	15.55	-4.26	36.80	37.19	1.38	52	52.30	-1.71
2	CMS 2 B	14.80	14.95	-4.86	35.40	35.79	-0.02	56	56.30	2.29
3	AKSF 7-2 B	19.20	19.35	-0.46	36.10	36.49	0.68	55	55.30	1.29
4	AKSF 6-3 B	20.50	20.65	0.84	37.20	37.59	1.78	60	60.30	6.39
5	CMS 302 B	22.10	22.25	2.44	38.00	38.39	2.58	57	57.30	3.29
6	AKSF 10-1-1 B	18.60	18.75	-1.06	38.50	38.89	3.08	60	60.30	6.29
7	AKSF 10-2-2 B	17.30	17.45	-2.36	39.50	39.89	4.08	59	59.30	5.29
8	CMS 607 B	20.80	20.95	1.14	38.20	38.59	2.78	58	58.30	4.29
9	CMS 138 B	23.40	23.55	3.74	37.30	37.69	1.89	58	58.30	4.29
10	CMS 148 B	17.20	17.35	-2.46	38.00	38.39	2.58	58	58.30	4.29
11	CMS 234 B	16.00	16.15	-3.66	39.10	39.49	3.68	56	56.30	2.29
12	IR-1-1R	20.10	20.25	0.44	35.50	35.89	0.08	55	55.30	1.29
13	R-271	23.50	23.65	3.84	34.60	34.99	-0.82	54	54.30	0.29
14	NDR-1R	27.50	27.65	7.84	36.00	36.39	0.58	51	51.30	-2.71
15	RHA-138-2R	30.50	30.65	10.84	36.40	36.79	0.98	50	50.30	-3.71
16	AK 345-2R	21.30	21.45	1.64	33.70	34.09	-1.72	53	53.30	-0.71
17	R-16R	22.00	22.15	2.34	35.40	35.79	-0.02	55	55.30	1.29
18	R-856	25.30	25.45	5.64	36.50	36.89	1.08	56	56.30	2.29
19	6-D-1R	25.50	25.65	5.84	35.40	35.79	-0.02	57	57.30	3.29

SN	Genotype	Seed yield (g/plot)			oil content (%)			DAS 50% flowering		
		UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect
20	P-144R	23.10	23.27	3.46	35.00	34.93	-0.88	51	51.30	-2.71
21	P-141R	23.50	23.67	3.86	36.00	35.93	0.12	52	52.30	-1.71
22	EC 601764	20.50	20.67	0.86	37.50	37.43	1.62	50	50.30	-3.71
23	EC 601729	18.00	18.17	-1.64	34.50	34.43	-1.38	54	54.30	0.29
24	EC 601768	18.40	17.57	-1.24	33.80	33.73	-2.08	53	53.30	-0.71
25	EC 601817	14.60	14.77	-5.04	35.40	35.33	-0.48	50	50.30	-3.71
26	EC 601725	18.60	18.77	-1.04	36.50	36.43	0.62	55	55.30	1.29
27	EC 601810	19.00	19.17	-0.64	34.10	34.03	-1.78	54	54.30	0.29
28	EC 601905	21.00	21.17	1.36	35.00	34.93	-0.88	52	52.30	-1.71
29	EC 601951	19.80	19.97	0.16	36.00	35.93	0.12	51	51.30	-2.71
30	EC 601958	16.70	16.87	-2.94	34.80	34.73	-1.08	50	50.30	-3.71
31	EC 601820	18.50	18.67	-1.14	35.60	35.53	-0.28	53	53.30	-0.71
32	EC 601939	24.20	24.37	4.56	36.80	36.73	0.92	55	55.30	1.29
33	EC 601961	23.50	23.67	3.86	37.50	37.43	1.62	50	50.30	-3.71
34	EC 601901	20.10	20.27	0.46	36.40	36.33	0.52	51	51.30	-2.71
35	EC 601812	28.70	28.87	9.06	35.10	35.03	-0.78	54	54.30	0.29
36	EC 6022011	24.50	24.67	4.86	36.20	36.13	0.32	56	56.30	2.29
37	EC 6023015	20.60	20.77	0.96	35.80	35.73	-0.08	57	57.30	3.29
38	EC 6023016	15.50	15.67	-4.14	36.30	36.23	0.42	52	52.30	-1.71
39	EC 6023020	16.40	16.07	-3.74	34.80	34.43	-1.38	53	52.70	-1.31
40	EC 6023021	14.50	14.17	-5.64	35.30	34.93	-0.88	51	50.70	-3.31
41	EC 6023025	13.00	12.67	-7.14	34.80	34.43	-1.38	50	49.70	-4.31
42	EC 6023027	17.20	16.87	-2.94	36.40	36.03	0.22	56	55.70	1.69
43	EC 6023028	14.00	13.67	-6.14	31.50	31.13	-4.68	58	57.70	3.69
44	EC 6023030	13.80	13.47	-6.34	36.00	35.63	-0.18	55	54.70	0.69
45	EC 6023031	15.00	14.67	-5.14	32.40	32.03	-3.78	58	57.70	3.69
46	EC 6023060	16.80	16.47	-3.34	35.80	35.43	-0.38	56	55.70	1.69
47	EC 6023072	17.00	16.67	-3.14	37.80	37.43	1.62	55	54.70	0.69
48	EC 512687	15.40	15.07	-4.74	38.40	38.03	2.22	52	51.70	-2.31
49	EC 512682	14.60	14.27	-5.54	36.40	36.03	0.22	50	49.70	-4.31
50	R-12	15.80	15.47	-4.34	35.00	34.63	-1.18	55	54.70	0.69
51	RHA-418R	17.60	17.27	-2.54	37.00	36.63	0.82	56	55.70	1.69
52	DOR-R-2-2	18.40	18.07	-1.74	36.00	35.63	-0.18	50	49.70	-4.31
53	DOR-R-2-1-2	19.50	19.17	-0.64	34.80	34.43	-1.38	59	58.70	4.69
54	BC-3-1R	18.50	18.17	-1.64	33.00	32.63	-3.18	53	52.70	-1.31
55	R 272	22.50	22.17	2.36	36.80	36.43	0.62	51	50.70	-3.31
56	AKSF 12 R	20.00	19.67	-0.14	35.00	34.63	-1.18	52	51.70	-2.31
57	AKSFI 27-1	20.50	20.17	0.36	35.20	34.83	-0.98	50	49.70	-4.31
58	AKSFI 31	18.50	18.51	-1.30	34.50	34.55	-1.26	55	54.70	0.69
59	AKSFI 49-1-1	19.50	19.51	-0.30	32.80	32.85	-2.96	48	47.70	-6.31
60	AKSFI 51-6-2	21.80	21.81	2.00	36.40	36.45	0.64	51	50.70	-3.31
61	AKSFI 143	20.80	20.81	1.00	35.50	35.55	-0.26	50	49.70	-4.31
62	AKSFI 150	25.50	25.51	5.70	35.00	35.05	-0.76	51	50.70	-3.31

SN	Genotype	Seed yield (g/plot)			oil content (%)			DAS 50% flowering		
		UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect
63	AKSFI-174	28.50	28.51	8.70	38.50	38.55	2.74	50	49.70	-4.31
64	AKSFI-205	23.50	23.51	3.70	34.80	34.85	-0.96	49	48.70	-5.31
65	AKSFI-209	16.50	16.51	-3.30	35.40	35.45	-0.36	50	49.70	-4.31
66	AKSFI-213	18.50	18.51	-1.30	32.20	32.25	-3.56	52	51.70	-2.31
67	AKSFI-214	20.50	20.51	0.70	34.50	34.55	-1.26	54	53.70	-0.31
68	AKSFI-215	21.30	21.31	1.50	33.70	33.75	-2.06	56	55.70	1.69
69	AKSFI-216	22.80	22.81	3.00	37.20	37.25	1.44	55	54.70	0.69
70	AKSFI-217	23.50	23.51	3.70	36.80	36.85	1.04	56	55.70	1.69
71	AKSFI-218	18.50	18.51	-1.30	36.90	36.95	1.14	54	53.70	-0.31
72	AKSFI-140	17.00	17.01	-2.80	33.60	33.65	-2.16	61	60.70	6.69
73	AKSFI-208	21.50	21.51	1.70	35.00	35.05	-0.76	62	61.70	7.69
74	AKSFI-17-1	26.20	26.21	6.40	36.20	36.25	0.44	56	55.70	1.69
75	AKSFI-17-2	28.40	28.41	8.60	34.60	34.65	-1.16	55	54.70	0.69
76	AKSFI-17-3	27.20	27.21	7.40	35.50	35.55	-0.26	50	49.70	-4.31
C1	CMS 17 B (C)	15.00			35.4			55		
C2	CMS 850 B (C)	14.83			37.4			57		
C3	ARM 243 B (C)	14.13			38.5			54		
C4	LTRR 341 (C)	16.53			35.5			53		
C5	RHA 1-1R (C)	13.68			36.5			60		
	Comparisons		S. E.	C.D. 95%		S.E.D.	C.D. 95%		S.E.D.	C.D. 95%
	Ci - Cj		**0.377**	**0.821**		**0.339**	**0.738**		**1.045**	**2.277**
	BiVi - BiVj		**0.754**	**1.642**		**0.677**	**1.476**		**2.090**	**4.553**
	BiVi - BjVj		**0.826**	**1.799**		**0.742**	**1.617**		**2.289**	**4.988**
	Ci - VI		**0.653**	**1.422**		**0.587**	**1.278**		**1.810**	**3.943**

Cont..

SN	Genotype	DAS to maturity			Pl. ht. (cm)			Head Diameter (cm)			100 seed wt. (g)		
		Un Adj. mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj. mean	Adj. mean	Effect
1	CMS 850 B	80	81.05	-1.69	128.5	128.88	11.26	13.7	13.75	0.66	5.4	5.44	1.09
2	CMS 2 B	84	85.05	2.31	175.2	175.58	57.96	13.8	13.85	0.76	5.0	5.04	0.69
3	AKSF 7-2 B	83	84.05	1.31	155.8	156.18	38.56	14.5	14.55	1.46	4.1	4.14	-0.21
4	AKSF 6-3 B	88	89.05	6.31	95.2	95.58	-22.04	15.0	15.05	1.96	8.5	8.54	4.19
5	CMS 302 B	82	83.05	0.31	128.6	128.98	11.36	13.5	13.55	0.46	3.8	3.84	-0.51
6	AKSF 10-1-1 B	87	88.05	5.31	126.4	126.78	9.16	14.5	14.55	1.46	4.2	4.24	-1.11
7	AKSF 10-2-2 B	85	86.05	3.31	120.7	121.08	3.46	13.5	13.55	0.46	6.0	6.04	1.69
8	CMS 607 B	83	84.05	1.31	140.0	140.38	22.76	12.5	12.55	-0.54	5.5	5.54	1.19
9	CMS 138 B	84	85.05	2.31	144.5	144.88	27.26	14.0	14.05	0.96	4.6	4.64	0.29
10	CMS 148 B	80	81.05	-1.69	148.3	148.68	31.06	14.5	14.55	1.46	4.8	4.84	0.49
11	CMS 234 B	84	85.05	2.31	150.5	150.88	33.26	14.2	14.25	1.16	3.6	3.64	-0.71
12	IR-1-1R	82	83.05	0.31	112.5	112.88	-4.74	13.5	13.55	0.46	4.0	4.04	-0.31

SN	Genotype	DAS to maturity			Pl. ht. (cm)			Head Diameter (cm)			100 seed wt. (g)		
		Un Adj. mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj. mean	Adj. mean	Effect
13	R-271	80	81.05	-1.69	105.1	105.48	-12.14	14.2	14.25	1.16	4.2	4.24	-0.11
14	NDR-1R	81	82.05	-0.69	100.5	100.88	-16.74	13.7	13.75	0.66	3.6	3.64	-0.71
15	RHA-138-2R	78	79.05	-3.69	114.8	115.18	-2.44	15.0	15.05	1.36	5.2	5.24	0.89
16	AK 345-2R	83	84.05	1.31	120.6	120.98	3.36	11.4	11.45	-1.64	4.1	4.14	-0.21
17	R-16R	85	86.05	3.31	108.6	108.98	-8.64	12.4	12.45	-0.64	4.6	4.64	0.29
18	R-856	84	85.05	2.31	105.1	105.48	-12.14	13.4	13.45	0.36	4.0	4.04	-0.31
19	6-D-1R	85	86.05	3.31	115.3	115.68	-1.94	14.0	14.05	0.96	4.5	4.56	0.19
20	P-144R	84	83.85	1.11	116.7	115.74	-1.88	12.5	12.35	-0.74	4.8	4.74	0.39
21	P-141R	83	82.85	0.11	119.1	118.14	0.52	13.4	13.25	0.16	5.0	4.94	0.59
22	EC 601764	82	81.85	-0.89	106.2	105.24	-12.38	10.5	10.35	-2.74	5.1	5.04	0.69
23	EC 601729	81	80.85	-1.89	104.8	103.84	-13.78	14.2	14.05	0.96	4.6	4.54	0.19
24	EC 601768	80	79.85	-2.89	100.5	99.54	-18.08	13.4	13.25	0.16	4.1	4.04	-0.31
25	EC 601817	83	82.85	0.11	124.5	123.54	5.92	15.0	14.85	1.76	3.8	3.74	-0.61
26	EC 601725	85	84.85	2.11	130.1	129.14	11.52	13.8	13.65	0.56	3.0	2.94	-1.41
27	EC 601810	86	85.85	3.11	128.7	127.74	10.12	12.4	12.25	-0.84	3.5	3.44	-0.91
28	EC 601905	82	81.85	-0.89	135.4	134.44	16.82	12.7	12.55	-0.54	4.0	3.94	-0.41
29	EC 601951	83	82.85	0.11	125.2	124.24	6.62	13.6	13.45	0.36	4.2	4.14	-0.21
30	EC 601958	81	80.85	-1.89	114.7	113.74	-3.88	12.8	12.65	-0.44	4.7	4.64	0.29
31	EC 601820	82	81.85	-0.89	100.6	99.64	-17.98	13.8	13.65	0.56	4.5	4.44	0.09
32	EC 601939	80	79.85	-2.89	110.2	110.24	-8.38	14.0	13.65	0.76	3.8	3.74	-0.61
33	EC 601961	85	84.85	2.11	107.8	106.84	-10.78	13.8	13.65	0.56	3.4	3.34	-1.01
34	EC 601901	84	83.85	1.11	110.1	109.14	-8.48	14.5	14.35	1.26	4.1	4.04	-0.31
35	EC 601812	85	84.85	2.11	135.6	134.64	17.02	12.6	12.45	-0.64	3.8	3.74	-0.61
36	EC 6022011	85	84.85	2.11	140.1	139.14	21.52	14.1	13.95	0.86	3.6	3.54	-0.81
37	EC 6023015	83	82.85	0.11	128.6	127.64	10.02	12.2	12.05	-1.04	4.8	4.74	0.39
38	EC 6023016	80	79.85	-2.89	125.4	124.44	6.82	13.4	13.25	0.16	4.1	4.04	-0.31
39	EC 6023020	81	80.25	-2.49	120.1	120.16	2.54	11.8	11.77	-1.32	3.4	3.44	-0.91
40	EC 6023021	80	79.25	-3.49	110.3	110.36	-7.26	14.5	14.47	1.38	4.9	4.94	0.59
41	EC 6023025	80	79.25	-3.49	104.7	104.76	-12.86	13.8	13.77	0.68	3.6	3.64	-0.71
42	EC 6023027	86	85.25	2.51	106.3	106.36	-11.26	14.2	14.17	1.08	3.8	3.84	-0.51
43	EC 6023028	85	84.25	1.51	115.4	115.46	-2.16	11.5	11.47	-1.62	4.0	4.04	-0.31
44	EC 6023030	83	82.25	-0.49	120.5	120.56	2.94	10.5	10.47	-2.62	4.6	4.64	0.29
45	EC 6023031	83	82.25	-0.49	146.1	146.16	28.54	11.8	11.77	-1.32	4.8	4.84	0.49
46	EC 6023060	84	83.25	0.51	126.7	126.76	9.14	12.0	11.97	-1.12	3.6	3.64	-0.71
47	EC 6023072	82	81.25	-1.49	146.5	146.56	28.94	14.5	14.47	1.38	4.3	4.34	-0.01
48	EC 512687	80	79.25	-3.49	115.2	115.26	-2.36	13.5	13.47	0.38	4.8	4.84	0.49
49	EC 512682	83	82.25	-0.49	100.8	100.86	-16.76	13.0	12.97	-0.12	3.7	3.74	-0.61
50	R-12	82	81.25	-1.49	105.3	10.36	-12.26	14.8	14.77	1.68	3.4	3.44	-0.91
51	RHA-418R	85	84.25	1.51	114.5	114.56	-3.06	13.6	13.57	0.48	4.7	4.74	0.39
52	DOR-R-2-2	80	79.25	-3.49	127.1	127.16	9.54	12.7	12.67	-0.42	4.5	4.54	0.19
53	DOR-R-2-1-2	88	87.25	4.51	164.8	164.86	47.24	11.8	11.77	-1.32	4.1	4.14	-0.21
54	BC-3-1R	84	83.25	0.51	155.5	155.56	37.94	13.5	13.47	0.38	3.5	3.54	-0.81
55	R 272	80	79.25	-3.49	125.4	125.46	7.84	14.2	14.17	1.08	4.4	4.44	0.09

SN	Genotype	DAS to maturity			Pl. ht. (cm)			Head Diameter (cm)			100 seed wt. (g)		
		Un Adj. mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj.mean	Adj. mean	Effect	UnAdj. mean	Adj. mean	Effect
56	AKSF 12 R	80	79.25	-3.49	114.0	114.06	-3.56	13.0	12.97	-0.12	4.9	4.94	0.59
57	AKSFI 27-1	80	79.25	-3.49	105.5	105.56	-12.06	13.5	13.46	0.38	4.3	4.34	-0.01
58	AKSFI 31	84	83.85	1.11	85.5	86.02	-31.60	11.0	11.15	-1.94	4.0	3.98	-0.37
59	AKSFI 49-1-1	80	79.85	-2.89	75.5	76.02	-41.60	10.5	10.65	-2.44	4.0	3.98	-0.37
60	AKSFI 51-6-2	82	81.85	-0.89	110.8	111.32	-6.30	14.2	14.35	1.26	4.8	4.78	0.43
61	AKSFI 143	80	79.85	-2.89	103.5	104.02	-13.60	12.5	12.65	-0.44	4.3	4.28	-0.07
62	AKSFI 150	80	79.85	-2.89	115.5	116.02	-1.60	15.5	15.65	2.56	5.5	5.48	1.13
63	AKSFI-174	82	81.85	-0.89	120.5	121.02	3.40	15.4	15.55	2.46	5.8	5.78	1.43
64	AKSFI-205	80	79.85	-2.89	110.2	110.72	-6.90	13.5	13.65	0.56	5.0	4.98	0.63
65	AKSFI-209	80	79.85	-2.89	85.5	86.02	-31.60	10.2	10.35	-2.74	3.8	3.78	-0.57
66	AKSFI-213	81	80.85	-1.89	105.5	106.02	-11.60	12.4	12.55	-0.54	3.5	3.48	-0.87
67	AKSFI-214	83	82.85	0.11	100.5	101.02	-16.60	11.5	11.65	-1.44	4.2	4.18	-0.17
68	AKSFI-215	81	80.85	-1.89	100.0	100.52	-17.10	10.2	10.35	-2.74	3.8	3.78	-0.57
69	AKSFI-216	85	84.85	2.11	95.5	96.02	-21.60	10.0	10.15	-2.94	3.6	3.58	-0.77
70	AKSFI-217	83	82.85	0.11	100.6	101.12	-16.50	11.7	11.85	-1.24	4.3	425	-0.07
71	AKSFI-218	81	80.85	-1.89	85.5	86.02	-31.60	11.0	11.15	-1.94	3.7	3.68	-0.67
72	AKSFI-140	90	89.85	7.11	95.0	95.52	-22.10	10.8	10.95	-2.14	3.3	3.28	-1.07
73	AKSFI-208	90	89.85	7.11	115.5	116.02	-1.60	12.5	12.65	-0.44	4.6	4.58	0.23
74	AKSFI-17-1	82	81.85	-0.89	118.5	119.02	1.40	13.0	13.15	0.06	4.5	4.48	0.13
75	AKSFI-17-2	80	79.85	-2.89	110.0	110.52	-7.10	12.7	12.85	-0.24	3.8	3.78	-0.57
76	AKSFI-17-3	80	79.85	-2.89	95.5	96.02	-21.60	11.0	11.15	-1.94	3.7	3.68	-0.67
C1	CMS 17 B (C)	84			120.5			13.5			4.8		
C2	CMS 850 B (C)	85			125.4			14.5			5.0		
C3	ARM 243 B (C)	83			120.5			13.5			4.9		
C4	LTRR 341 (C)	81			125.8			14.3			5.1		
C5	RHA 1-1R (C)	88			120.5			12.5			4.7		
	Comparisons		S.E.D.	C.D. 95%		S.E.D.	C.D. 95%		S.E.D.	C.D. 95%		S.E.D.	C.D. 95%
	Ci - Cj		0.756	1.646		1.213	2.642		0.180	0.392		0.173	0.377
	BiVi - BiVj		1.511	3.292		2.425	5.284		0.360	0.784		0.346	0.754
	BiVi - BjVj		1.655	3.606		2.657	5.789		0.394	0.858		0.379	0.826
	Ci - Vi		1.309	2.851		2.100	4.576		0.312	0.679		0.300	0.653

□□□

Assessment of Genetic Divergence and Correleation for Seed Releated Characters in Germplasm of Safflower

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Abstract: Safflower (*Carthamus tinctorius L.*) is one of such popular *rabi* crop which has a high adaptation to different conditions such as resistance to drought and it is suited to be grown in arid and semiarid regions. The investigation on genetic diversity studies in safflower germplasm was undertaken to estimate the extent of diversity and to estimate the contribution of each character towards genetic diversity. The set of 63 genotypes along with three checks 'A-1, PBNS-12, PKV Pink' were evaluated at the field of Oilseeds Research Unit, Dr. PDKV, Akola during rabi 2018-2019. The more diverse parent, the greater are the chances of obtaining higher amount of heterotic expression in F1 and broad spectrum of variability in segregating generations. The present study was undertaken to estimate the extent of diversity and to estimate the contribution of each character towards genetic diversity.The trait seed yield per plant had contributed maximum (25.69%) towards total divergence followed by days to maturity (18.41%), days to 50% flowering (16.08%), number of seeds per capitulum (12.82%), plant height (10.58%), volume weight (8.34%), number of capitula per plant (6.62%), oil content (0.98%) number of branches per plant (0.47%).Based on maximum intercluster distance, ten different potential cross combinations have been suggested viz., GMU-7590 x GMU-972 for high oil with earliness and high yield potential, GMU- 4914 x GMU-972 for earliness with moderate volume weight and high yield potential, GMU-590 x GMU-7590 for high plant height with high oil, GMU-2830 x GMU- 972 for high oil with earliness, GMU-3438 x GMU-4914 for high hundred seed weight with earliness, GMU-7590 x GMU-6852 for high plant height and high oil with earliness. Genetic variability and correlation among seed yield and yield attributes help in identifying a suitable genotype with desired characteristics. Correlation coefficient analysis could indicate significant relationship among the evaluated traits. However, a genotype with both high yield and high oil content could be more useful for strengthening breeding programme.

Key words: Safflower, Genetic Diversity, Genetic Variability, Correlation

Introduction

Oilseed crops are the main source of edible oils with healthy diet and compared to synthetic and animal fat and have become more popular with high demand among consumers. Safflower (*Carthamus tinctorius L.)* is one of such popular rabi crop which has a high adaptation to different conditions such as resistance to drought and it is suited to be grown in arid and semi-arid regions. In order to design an appropriate breeding programme, it is important to know how much the phenotypic variation of the trait is heritable, since the efficiency of selection programme is mainly dependent on the magnitude of genetic variation and heritability of the trait (Falconer and Mackay, 1996). The selection of parents for hybridization determines the success of breeding programme. The genetic diversity is the basis of plant breeding created due to inherent genetic differences in the plant species and is of major interest to plant breeder. The more diverse parent, the greater are the chances of obtaining higher amount of heterotic expression in F1 and broad spectrum of variability in segregating generations. The present study was undertaken to estimate the extent of diversity and to estimate the contribution of each character towards genetic diversity. It is an important oilseed crop as it contains 78 per cent of PUFA (Linoleic Acid) which is useful for heart patients as it reduces blood cholesterol levels (Nimbkar 2002). It also contains 16-20 per cent monosaturated fatty acid (Oleic Acid) and only 8 per cent saturated fatty acid 2-3 per cent stearic acid, 6-8 per cent palmitic acid (Hamdan et al., 2011). Improvement in the seed yield per plant is an important activity of plant breeding. The ultimate seed yield is a complex process that will be affected by many genetic and non-genetic factors. Correlation coefficient is an important statistical constant which indicate the degree of association among the various characters. In order to know the magnitude of association of the seed yield with other yield influencing traits, correlation analysis is an effective tool. This will help in constructing a suitable plant type and combining desirable expression of different yield components. The present investigation therefore was planned to evaluate the genetic correlation studies in germplasm accessions of safflower.

Material and Methods

The experimental material consisted of 63 germplasm lines of safflower along with three checks A-1, PBNS-12 and PKV Pink. These were evaluated in augmented design, in a single row plot of five metre length at the field of Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during rabi season 2018-19. The experimental design consisted of seven block design with each block containing nine germplasm lines and three checks. Checks were common for every block. All recommended cultural practices were followed to raise a good crop. The observations were recorded on five randomly selected plants for ten quantitative traits viz., days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of capitula per plant, number of seeds per capitulum, volume weight (g/100ml), 100 seed weight (g), oil content (%) and seed yield per plant (g). The data was subjected to D2 statistics as described by Rao (1952) [5] and genotypes were grouped into different clusters by following Tocher's method using Windstat statistical software whereas, the data were subjected to simple correlation analysis as per Singh and Choudhary (1977).

Results and Discussion

To analyze genetic diversity among these genotypes, D2 analysis was carried out. The variation among the genotypes were significant for days to 50% flowering, days to maturity, plant height, number of branches per plant, number of capitula per plant, number of seeds per capitulum, 100 seed weight, volume weight, oil content, seed yield per plant indicating the presence of wide genetic variability for these characters. Variation among the entries was also significant for all characters. The 63 genotypes and 3 checks were grouped into ten clusters by the Tocher's method as shown in Table 1. Cluster I was the largest involving 44 genotypes with checks A-1, PBNS-12 and PKV Pink. The next largest cluster was cluster II with14 genotypes. Cluster III, IV, V, VI, VII, VIII, IX, X involved only one genotype in each cluster.

Table 1: Grouping of genotypes into different clusters

Cluster	No. of Genotypes	Name of Genotypes
1	44	GMU-1758, GMU-5142, GMU-7351, GMU-7355, GMU-7359, GMU-1654, GMU-5149, GMU-2687, GMU-2648, PKV PINK, GMU-3266, GMU-5136, GMU-2347, GMU-2928, GMU-880, GMU-7363, GMU-7456, GMU-955, GMU-2644, A-1, GMU-1798, GMU-1067, GMU-2757, GMU-5135, GMU-5134, GMU-2273, GMU-3944, GMU-2424, GMU-2403, GMU-5133, GMU-667, GMU-1360, GMU-184, GMU-3206, GMU-5097, GMU-974, GMU-609, GMU-884, PBNS-12, GMU-1811, GMU-2486, GMU-2775, GMU-6891, GMU-7593
2	14	GMU-1731, GMU-7591, GMU-1397, GMU-7618, GMU-1894, GMU-7573, GMU-7448, GMU-7581, GMU-6926, GMU-753, GMU-4983, GMU-579, GMU-2830, GMU-589
3	1	GMU-590
4	1	GMU-7569
5	1	GMU-3438
6	1	GMU-7590
7	1	GMU-2380
8	1	GMU-972
9	1	GMU-6852
10	1	GMU-4914

The cluster means of all the 10 characters had presented in the Table 2. For days to 50% flowering, least cluster mean was recorded by cluster VIII (64.38), For days to maturity cluster VIII (96.71) showed least cluster mean. In case of 100 seed weight, the highest cluster mean was observed in cluster IX (3.61), for oil content it was highest for cluster VI (36.08), for seed yield per plant (g) highest cluster mean as cluster V (46.39) followed by cluster VIII (45.65). The trait seed yield per plant had contributed maximum (25.69%) towards total divergence followed by days to maturity (18.41%), days to 50% flowering (16.08%), number of seeds per capitulum (12.82%), plant height (10.58%), volume weight (8.34%), number of capitula per plant (6.62%), oil content (0.98%) number of branches per plant (0.47%). While 100 seed weight has not shown any contribution towards genetic divergence in the present study. Similar results were also obtained by Tayade (2015) and Atole (2018) (Table 3).

Table 2 : Cluster means for ten characters

	DAS 50% flower-ing	DAS maturity	Plant height (cm)	No. of branches / plant	No. of capitula/ plant	No. of seeds/ capitulum	100 seed wt. (g)	Volume wt. (g/ 100 ml)	Oil content (%)	Seed yield/plant (g)
Cluster I	80.42	113.52	58.33	8.82	20.41	24.7	3.44	42.13	26.16	39.99
Cluster II	88.69	123.52	57.67	7.98	10.79	20.79	2.99	37.76	29.7	24.21

Cluster III	70.38	106.38	57.32	9.1	17.14	11.48	3.01	36.4	24.74	30.35
Cluster IV	83.71	117.05	35.92	6.43	8.81	16.14	3.11	36.97	22.64	21.19
Cluster V	88.57	131.71	65.2	12.71	22.86	30.43	3.17	44.63	30.76	46.39
Cluster VI	104.05	132.05	56.92	8.76	10.81	39.48	2.55	31.83	36.08	27.75
Cluster VII	86.38	112.71	64.36	7.1	16.48	43.48	2.41	38.7	24.54	34.42
Cluster VIII	64.38	96.71	52.12	10.43	21.48	26.14	3.41	51.33	28.58	45.65
Cluster IX	78.71	120.05	40.72	5.43	27.81	15.14	3.61	36.97	24.84	28.39
Cluster X	82.71	119.05	56.62	5.43	10.81	23.14	3.11	10.17	26.64	25.79

Table 3: Contribution of each character towards genetic divergence

Source	Times rank first	% contribution
Days to 50% flowering	345	16.08
Days to maturity	395	18.41
Plant height (cm)	227	10.58
No. of branches/plant	10	0.47
No. of capitula/plant	142	6.62
No. of seeds/capitulum	275	12.82
100 seed weight (g)	0	0
Volume weight (g)	179	8.34
Oil content (%)	21	0.98
Seed yield/plant (g)	551	25.69

The present study has helped to identify diverse parents for hybridization programmed based on mean performance and cluster formed. The genotypes identified for different characters for further breeding programme are given in Table 4. The present study projected the importance of GMU-7363, GMU-5135, GMU-5134 as parents for higher heterosis in F1 and potential transgrassivesegregants in subsequent generations as they have least mean for days to maturity, whereas high mean of GMU-7448, GMU-5136, GMU-2648, GMU-2928, GMU-667, GMU-1798, GMU-2830 and GMU7355 for characters viz plant height, number of branch per plant, number of capitula per plant, number of seeds per capitulum, 100 seed weight, volume weight, oil content and seed yield per plant respectively for their further improvement in respect to yield contributing characters.

Table 4: Genotype selected for different characters on the basis of cluster formed

Sr. No.	Character	Cluster	Genotypes selected from cluster formed
1	Early maturity (days)	I	GMU-7363(96.71),GMU-5135(104.71), GMU-5134(105.71)
		VIII	GMU-972(106.38)
2	Maximum plant height (cm)	II	GMU-7448(69.92)
		I	GMU-2757(68.76), GMU-1360 (67.79)
		IV	GMU-7569(67.12)
3	Maximum no. of branches	I	GMU-5136 (17.76), PKV Pink (12.71), GMU-2486(12.10)
4	Maximum no. of capitula/plant	I	GMU-2648(31.48),GMU-7351 (29.81), GMU-1360(27.81)
5	Maximum no. of seeds/ capitulum	I	GMU-2928(43.48), GMU-7359(40.48)
		II	GMU-7581 (39.48), GMU-1397(37.14)
6	Maximum 100 seed wt. (g)	I	GMU-667(4.51), GMU-1067(4.41), GMU-884(4.31)
		V	GMU-3438 (4.41)
		II	GMU-1894(4.41)
7	Maximum volume weight (g/100 ml)	I	GMU -1798(53.23), GMU-667 (52.20), GMU-7363(51.33)
8	High oil content (%)	II	GMU-2830(37.37),GMU-7591(36.78), GMU-7581(36.08)
9	Maximum seed yield (g)	I	GMU-7355(50.19),GMU-3266(49.12), GMU-1067 (48.95)

Based on maximum intercluster distance, ten different potential cross combinations have been suggested as mentioned in the Table 5. GMU-7590 x GMU-972 for high oil with earliness and high yield potential, GMU- 4914 x GMU-972 for earliness with moderate volume weight and high yield potential, GMU-590 x GMU-7590 for high plant height with high oil, GMU-2830 x GMU- 972 for high oil with earliness, GMU-3438 x GMU-4914 for high hundred seed weight with earliness, GMU-7590 x GMU-6852 for high plant height and high oil with earliness.

The correlation coefficient between ten traits is presented in Table 6. Correlation analysis showed that days to 50% flowering (-0.10) and days to maturity (-0.05) were negatively correlated with seed yield per plant. These results were in conformity with the results obtained by Anjani (2005) and Salunkhe (2014). Plant height (0.30*) had significant positive association with seed yield per plant. Similar results were obtained by Salunkhe (2014).

Table 5: Maximum intercluster distance and Cross combination suggested

Sr. No.	Cluster combination	Average intercluster distance	Cross combination ssuggested	Characters to be improved
1	VI x VIII	3896.92	GMU-7590 x GMU-972	High oil with earliness and high yield potential
2	X x VIII	3096.12	GMU- 4914 x GMU-972	Earliness with moderate volume weight and high yield potential
3	III x VI	2772.88	GMU-590 x GMU-7590	High plant height with high oil
4	II x VIII	2383.65	GMU2830 x GMU-972	High oil with earliness
5	V x IV	2296.31	GMU-3438 x GMU-7590	High 100 seed weight With high plant height
6	VIII x IV	2166.42	GMU-972 x GMU-7569	Earliness with plant height
7	V x X	2148.52	GMU-3438 x GMU-4914	High100 seed weight with earliness
8	VI x IX	2094.52	GMU-7590 x GMU-6852	High plant height and high oil with earliness
9	V x VIII	2056.97	GMU-3438 x GMU-972	High100 seed weight with earliness
10	VI x IV	1883.58	GMU-7590 x GMU-7569	High oil with High plant height

Table 6: Simple correlation among ten yield contributing characters of safflower genotypes

	DAS 50% flowering	DAS maturity	Plant height (cm)	No. of branches/ plant	No. of capitula/ plant	No. of seeds/ capitulum	100 seed wt. (g)	Volume wt. (g/ 100 ml)	Oil content (%)	Seed yield/ plant (g)
Days to 50% flowering	1.00	0.60	0.28*	-0.03	-0.16	0.22	-0.05	-0.28*	0.42**	-0.10
Days to maturity		1.00	0.25*	0.14	-0.02	0.08	0.03	-0.10	0.34**	-0.05
Plant height (cm)			1.00	0.21	0.21	0.39**	0.08	0.21	0.31*	0.30*
No. of branches/plant				1.00	0.37**	0.25*	-0.03	0.32**	0.09	0.38**
No. of capitula/plant					1.00	0.23	0.30*	0.41**	-0.16	0.72**
No. of seeds/capitulum						1.00	-0.02	0.15	0.17	0.32**
100 seed weight (g)							1.00	0.33**	-0.31*	0.39**
Volume weight (g/100 ml)								1.00	-0.08	0.47**
Oil content (%)									1.00	-0.18
Seed yield/ plant (g)										1.00

Note-* Significance at 5% level , ** Significance at 1% level

Number of branches per plant (0.38**) was significantly and positively correlated with seed yield per plant. Salunkhe (2014) recorded the similar results.

Positive and significant association of number of capitula per plant (0.72**) with seed yield was obtained. These results were in conformity with the results obtained by Mohamed (2018).

Number of seeds per capitulum (0.32**) was positively and significantly associated with seed yield per plant. Similar results were obtained by Mohamed (2018).

Significant positive association between 100 seed weight (0.39**) and seed yield per plant was obtained. Jadhav et al. (2018) obtained similar results.

Volume weight (0.47**) was positively and significantly associated with seed yield per plant. Negative and non-significant association of oil content (-0.18) with seed yield per plant was obtained. Existence of strong negative association between these components was also reported by Hoshang et al. (2013)and Salunkhe (2014). This indicates that a high yielding genotype need not necessarily have high oil content. However, a genotype with both high yield and high oil content could be the ultimate achievement.

Conclusion

This study aimed at selecting such desirable genotypes. Genetic variability and correlation among seed yield and yield attributes help in identifying a suitable genotype with desired characteristics.

Implication

The success of selection depends on the choice of selection criteria for improvement of seed yield. Correlation coefficient analysis could establish significant relationship among the evaluated traits.

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Evaluation of *Rhizobium* Isolates Against Nodulation and Grain Yield of Greengram

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Abstract: To study the effect of different selected *Rhizobium* isolates against nodulation and grain yield of Greengram variety AKM-8802, a field experiment was conducted at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). The experiment comprising of eight treatments including control and a treatment of recommended dose of chemical fertilizer with six treatments of *Rhizobium* isolates which were procured from different agro climatic regions of India. Experiment was laid out in RBD with three replications. The carrier based culture of *Rhizobium* isolates were inoculated @ 25 g/kg of seed. From the above results, it is indicated that the seed inoculation of *Rhizobium* isolate (AKMR-12-01) recorded higher grain yield (522 kg/ha) and maximum number of nodulation (25.20 nodules /plant) among the isolates.

Key words: Greengram; *Rhizobium*; Nodulation; Yield; Biofertilizers

Introduction

The use of fertilizers, including chemical fertilizers and manures to enhance soil fertility and crop productivity has often negatively affected the complex system of the biochemical cycles (Steinshamn *et al.*, 2004). In the last five decades, the rate of nitrogen, phosphorous and potassium (NPK) fertilizer application has increased tremendously. The international fertilizer industry reported that three countries with the highest fertilizer use in 2006, where China, India and USA consuming 50.15, 21.65 and 20.83 million tons of fertilizer, respectively. The challenge therefore, is to continue agricultural productivity in a way that minimizes harmful environmental effects of fertilizers. Every increasing population of the world demands the increase in food production which depends upon the improved agriculture practices.

Greengram (*Vigna radiata* L. Wilczek) also known as Mungbean, is one of the important legume pulse crops of India. It is a good source of protein, carbohydrates, calcium and phosphoric acid. It also helps in soil erosion. In India green gram is grown in Orissa, Maharashtra, Andhra Pradesh, Gujrat, Rajastan and Bihar. Mungbean is digestible, high in protein (22 - 24%; Malik, 1994) and does not cause flatulence that many other legumes do. Moreover, it is rich in vitamins as A, B, C, niacin, and minerals such as potassium, phosphorus and calcium, which are necessary for human body (Rattanawongsa, 1993). Owing to all these characteristics it is a good substitute of animal protein and forms a balanced diet when it is taken with cereals. (Ahmed *et al* 2006)

Several factors are responsible for high production of greengram. One of the most important effective factors in increasing of grain yield is seed priming (inoculation) with plant growth promoting rhizobacteria.

Rhizobium species have been defined in terms of cross-inoculation groups among legumes. *Rhizobium* invades the root hairs of greengram and result in the formation of nodules, where free air nitrogen is fixed. These bacteria, although present in most of the soils vary in number, effectiveness in nodulation and N_2-fixation. It has been argued that usual native soil rhizobial populations are inadequate and are ineffective in biological nitrogen fixation. To ensure an optimum rhizobial population in the rhizosphere, seed inoculation of legumes with an efficient rhizobial strain is necessary. This helps improve nodulation, N_2–fixation, solicit improved growth and yield of leguminous crops (Henzell, 1988).

Increased grain legume production depends on effective inoculants containing high numbers (> 10^7/g) of effective *Rhizobium* must withstand adverse field condition (R.J.Kremer & H.L. Peterson, 1983). It is an established fact that *Rhizobia* fix nitrogen and play role in improving plant growth. Several workers have reported that seed inoculation with *Rhizobium* has significantly increased the growth and yield of legume crops (Pathak *et. al.*, 2001). With this view, the present study was taken up to evaluate the performance of different *Rhizobium* isolates on nodulation and seed yield of greengram.

Materials and Methods

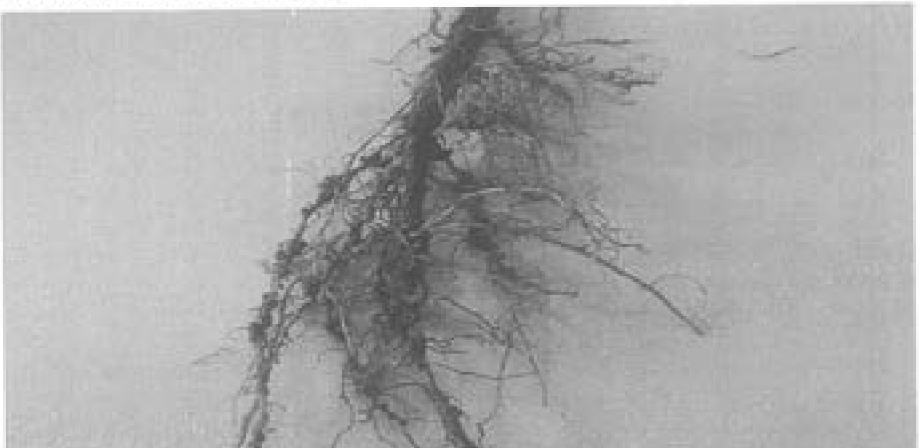
To evaluate the response of *Rhizobium* isolates in greengram, a field experiment was conducted during *kharif* 2019-20 at Pulses Research Unit, Dr. PDKV, Akola (M.S). The experiment was laid out in completely randomized block design with eight treatments. Besides control without inoculation and basal dose of inorganic N at 20 kg N ha^{-1}, there were six treatments of different *Rhizobium* isolates obtained from AICRP Pulses centers from all over India. Seeds were inoculated with respective carrier base culture of *Rhizobium* inoculants prior to sowing using 25 g kg^{-1} of seed. Each treatment has gross plot size 3.80 X 2.40 m^2 and net plot 2.80 X 1.80 m^2 and replicated thrice with local greengram variety AKM-8802. The data on plant dry weight and nodulation was recorded at 35 DAS from five randomly selected plants from each plot. The roots of uprooted plants were gently washed with water and counted the pink colour active nodules only and after drying the nodules, weight of dried nodules were recorded. Seed yields were also recorded after crop harvest. The data collected during this study was subjected to statistical analysis variance (ANOVA) to compare the difference among all the treatments. (James *et.al.*,1997).

Table: Effect of different *Rhizobium* isolates on nodulation and grain yield of Green gram

Sr. No.	Isolates	No. of nodules/pl	Nodule dry wt/pl (mg)	Plant dry wt./pl (gm)	Grain yield (kg/ha)
1	AKMR-12-01	25.20	70.11	4.28	522
2	PMR-1	23.00	64.50	4.12	504
3	VMC	19.27	50.02	3.76	469
4	VMF	17.80	46.00	3.69	435
5	MOR-5	21.80	60.31	3.92	490
6	MOR-6	19.00	48.33	3.73	460
7	20 kg N/ha	14.00	34.05	4.77	609
8	Uninoculated Control	11.33	25.10	3.19	381
	S.E. + (m)	0.69	1.62	0.29	36
	C.D. p = 0.05	2.04	4.73	0.86	106

Result and Discussion

Effect on Nodulation: Table shows the treatments of application of seed inoculation with microorganisms and nitrogen fertilizer significantly increase the nodules number over uninoculated control (11.33 nodules $plant^{-1}$). The data of the table is indicated that the *Rhizobium* isolate AKMR-12-01 recorded the highest nodule number (25.20 $plant^{-1}$) and was followed by *Rhizobium* PMR-1 (23.00 $plant^{-1}$) and MOR-5 (21.80 $plant^{-1}$). The variation in nodule number was due to better compatibility and efficiency of inoculated *Rhizobium* compared to the native rhizobia in forming effective nodules in the rhizosphere of greengram. Ahmed *et al* (2006) reported that application of inoculation treatment and nitrogen fertilizer significantly affected number of nodules and the treatments significantly differed from each other as compared to the control. Also the present results are confirmatory with the findings of Chandra *et al*. (2002). .



Photograph showing active nodulation to Green gram plant due to AKMR-12-01 isolate.

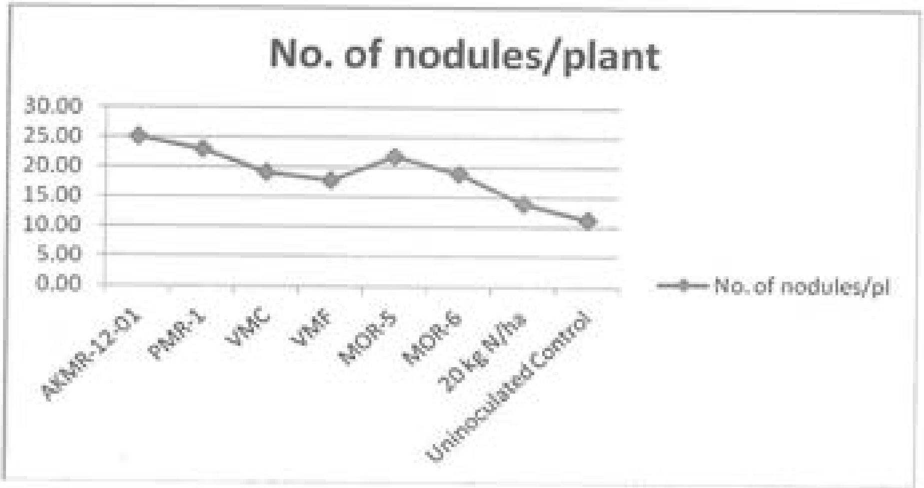


Fig.1: Effect of seed inoculation with different *Rhizobium* isolates on nodulation of Greengram

Effect on Nodules and plan dry weight

Nodules dry weight and plant dry weight differences among all the *Rhizobium* inoculation were significant. Among the inoculated treatments, highest nodules dry weight (70.11 mg/plant) and plant dry weight (4.28 g/plant) were observed in the seed inoculation with *Rhizobium* AKMR-12-01 while least nodules dry weight (25.10 mg/plant) and plant dry weight (3.19 g/plant) was recorded in the uninoculated control. These results are in the pipeline with the findings of Saleh *et al.* (2013). Similar results of Waseem Raza et al (2004), who reported that dry weight of nodules and plant biomass was increased with *Rhizobium* inoculation over control without inoculation.

Effect on grain yield

All the inoculated *Rhizobium* isolates significantly increased the grain yield by 12.41 to 27.01% over uninoculated control (381 kg ha^{-1}). The seed inoculation with *Rhizobium* isolate AKMR-12-01 recorded the highest grain yield of 522 kg ha^{-1} followed by *Rhizobium* isolate PMR-1 (504 kg ha^{-1}). Yield advantages over uninoculated control occurred due to seed inoculation of *Rhizobium* AKMR-12-01 and PMR-1 by 27.01 and 24.40% respectively. Increased in grain yield could be due to attributed to better crop growth, better nodulation and improvement of yield attributes due to seed inoculation with efficient *Rhizobium* isolates. The results of increased grain yield due to efficient isolates of *Rhizobium* are in agreement with the finding of Saini and Khanna (2012). *Rhizobium* isolates are good candidates to be developed as biofertilizers for N_2 fixation, growth promotion and yield enhancement in greengram was reported by Gurubasayya Kallimath and C.R.Patil , (2018).

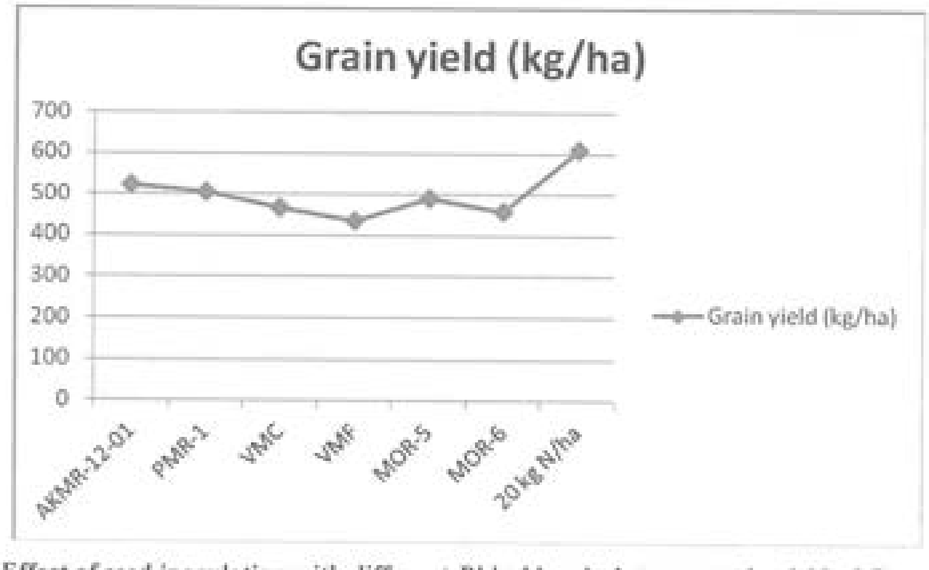


Fig.2: Effect of seed inoculation with different *Rhizobium* isolates on grain yield of Green gram

Summary and Conclusion

In this investigation, *Rhizobium* isolate AKMR-12-01 recorded the highest nodule number (25.20 $plant^{-1}$) followed by *Rhizobium* PMR-1 (23.00 $plant^{-1}$). Nodules dry weight and plant dry weight differences among all the *Rhizobium* inoculation were significant. All the inoculated *Rhizobium* isolates significantly increased the grain yield by 12.41 to 27.01% over uninoculated control (381 kg ha^{-1}).

Seed inoculation with appropriate efficient *Rhizobium* isolates would be the best suitable option for improving the nodulation and yield of green gram.

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Productivity and Economics of Fodder Maize Varieties as Influenced by de-topping Practices and Nitrogen Levels

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Abstract: A field experiment entitled "Productivity and economics of fodder maize varieties as influenced by de-topping practices and nitrogen levels was conducted during *kharif* season of 2018 at Department of Agronomy, Dr. P.D.K.V., Akola The experiment was laid out in split plot design with three replications. Experimental results revealed that treatments no de-topping produced significantly greater yield attributes and grain yield ha^{-1} and monetary returns viz., gross, net returns and B : C ratio over de-topping treatment. Fodder yield ha^{-1} was maximum with variety African tall as compared to Pioneer-3296. However, yield attributes, grain yield ha^{-1}, gross and net monetary returns ha^{-1} and B:C ratio were recorded significantly maximum with variety Pioneer-3396 over African tall. Increased levels of nitrogen increased yield attributes, grain yield and monetary return was greater with application of 150 Kg N ha^{-1} as compared to application of 100 Kg N ha^{-1}, 50 Kg N ha^{-1} and control, respectively.

Introduction

Availability of green forage to animals is the key to success of dairy enterprise and it is difficult to maintain the health and milk production of the livestock without supply of the green fodder. Fodder maize (*Zea mays L.*) is one of the most important dual-purpose crops grown throughout year. Nitrogen is a primary nutrient required by crop plants for their growth and development. The application of nitrogen not only affects the forage yield of maize, but also improves its quality especially its protein contents. It is reported that application of nitrogen to maize increase fodder nutritive value by increasing crude protein and by reducing ash and fiber contents. Plant height, stem diameter, green fodder yield and protein, fiber, and total ash content were increased by increasing nitrogen levels. De-topping refers to nipping or the removal of terminal portion from the uppermost node to improve the yield through greater functioning of remaining leaves by arresting unnecessary growth, decreasing mutual shading of leaves, enhancing light interception, increasing nutrient uptake, decreasing competition between the tassel and cob for available plant nutrients, diverting plant nutrients to the reproductive part which aids in better source-sink relationship and better cob development. De-topping has the additional advantages of controlling lodging in case of excessive vegetative growth and provide green fodder to animals and without sacrificing the grain yield. Proper time of de-topping seems to be very important for controlling lodging and obtaining enough forage without sacrificing grain yield. Keeping in view the above consideration a field investigation entitled "Productivity and economics of fodder maize varieties as influenced by de-topping practices and nitrogen levels" planned with objective to influence of de-topping and maize varieties on productivity and economics of fodder maize.

Material and Methods

A field experiment entitled "Evaluation of fodder value of maize varieties as influenced by nitrogen levels and de-topping was conducted during *kharif* season of 2018 at Department of Agronomy, Dr. P.D.K.V., Akola The experiment was laid out in split plot design with three replications keeping four combination of two de-topping practice (D_1 : No de-topping and D_2 : De-topping after 15 days tasseling) and two varieties (V_1 : African tall and V_2 : Pioneer-3396) under main plot and four nitrogen levels (N_0- 0 Kg, N_1-50 Kg, N_2 -100 Kg and N_3 - 150 Kg N ha^{-1}, respectively) under sub plot. The gross and net plot sizes were 3.6 X 4.0 m^2 and 3.0 X 3.6 m^2 respectively. Recommended dose of fertilizers i.e. N applied as per treatments in two split *i.e* 50% as basal dose and remaining 50 % at 30 after sowing days as top dressing and dose of 60:60 Kg/ha P and K is common to all treatments, respectively.

Results and Discussion

Effect of no de-topping and de-topping

Yield attributes viz., weight of cob (g), number of grains per cob were significantly influenced by no de-topping and de-topping treatment. Significantly maximum weight of cob (197.85 g) and number of grains (502.36) was recorded with no de-topping over the de-topping (Table 1). Significantly highest grain yield (Table 2) was recorded in (D_1) no de-topping (3923 Kg ha^{-1}) over (D_2) de-topping (3123 Kg ha^{-1}). However, treatment (D_2) de-topping (7339 Kg ha^{-1}) recorded significantly maximum fodder yield over (D_1) no de-topping (6096 Kg ha^{-1}). The findings are in accordance with those of Jalilian and Delkhoshi (2014). Significantly highest gross monetary return (Table 2) was obtained with (D_1) no de-topping Rs 90754 ha^{-1} over (D_2) de-topping Rs 84236 ha^{-1}. Significantly highest net monetary return was obtained with (D_1) no de-topping (Rs. 58868 ha^{-1}) over (D_2) de-topping (Rs. 50050 ha^{-1}).

Effect of varieties

Yield attributes viz., length of cob, weight of cob, girth of cob, number of grains, and test weight were significantly influenced by the type of varieties. Significantly higher yield attributes was recorded with grain type variety (V_2) Pioneer-3396 over the fodder type variety (V_1) African tall (Table 1). Significantly highest grain yield was recorded with (V_2) Pioneer-3396 (4459 Kg ha^{-1}) over the (V_1) African tall (2567 Kg ha^{-1}). However, significantly highest fodder yield was recorded with (V_1) African tall (7518 Kg ha^{-1}) over the (V_2) Pioneer-3396 (5917 Kg ha^{-1}). The greater yield in grain type variety Pioneer-3396 might be due to high yield genetic potential as compared to fodder type variety which yields less is common phenomenon. Similar results were also reported by Massy and Gaur (2006) (Table 2). Significantly highest gross monetary return was recorded in (V_2) Pioneer-3396 (Rs. 100363 ha^{-1}) over the (V_1) African tall (Rs. 74627 Rs ha^{-1}). Significantly highest net monetary return was recorded in Pioneer-3396 (Rs. 64427 ha^{-1}) over African tall (Rs. 44491 ha^{-1}). Similar research trend was also found Massy and Gaur (2006). In case of varieties highest benefit cost ratio was registered with (V_2) Pioneer-3396 (2.78) over (V_1) African tall (2.43) (Table 2).

Table 1. Yield attributes viz., (Length of cob, weight of cob, girth of cob, number of grains, and test weight) of maize influenced by various treatments.

Treatments	Length of cob (cm)	Weight of cob (g)	Girth of cob (cm)	Number of grains/cob	100 seed weight (g)
Main plot					
A. De-topping					
D_1 : No de-topping	17.45	197.85	14.48	502.36	28.07
D_2 : De-topping	17.17	178.26	14.76	435.26	26.93
SE (m) ±	0.26	3.35	0.22	4.05	0.48
CD at 5 %	NS	11.56	NS	13.97	NS
B. Varieties					
V_1 : African tall	16.64	177.27	13.17	452.55	25.60
V_2 : Pioneer-3396	17.98	198.83	16.07	485.07	29.39
SE (m) ±	0.26	3.35	0.22	4.05	0.48
CD at 5 %	0.90	11.56	0.76	13.97	1.66
Sub plot					
C. N levels					
N_0 : 0 Kg ha^{-1}	15.36	173.57	14.33	371.52	26.13
N_1 : 50 Kg ha^{-1}	15.99	177.93	14.43	435.45	27.50
N_2 :100 Kg ha^{-1}	17.82	198.13	14.70	524.35	27.56
N_3 :150 Kg ha^{-1}	20.07	202.59	15.03	543.92	28.80
SE (m) ±	0.18	3.82	0.75	10.71	0.25
CD at 5 %	0.54	11.15	0.21	31.28	0.74
Interactions	**Interaction effects of D X V, D X N, V X N and D X V X N were found to be NS**				
GM	**17.31**	**188.05**	14.63	**468.81**	**27.49**

Table 2. Grain, fodder, biological yield (Kg ha^{-1}) and gross, net monetary returns (Rs ha^{-1}) and benefit cost ratio of maize influenced by various treatments.

Treatments	Yield (Kg $^{ha-1}$)		Monetary returns (Rs ha^{-1})		B:C Ratio
	Grain	Fodder	Gross	Net	
Main plot					
A. De-topping					
D_1 : No de-topping	3923	6096	90754	58868	2.83
D_2 : De-topping	3123	7339	84236	50050	2.43
SE (m) ±	104	179	1529	1529	-
CD at 5 %	361	620	5280	5280	-
B. Varieties					
V_1 : African tall	2567	7518	74627	44491	2.48
V_2 : Pioneer-3396	4459	5917	100363	64427	2.78
SE (m) ±	104	179	1529	1529	-
CD at 5 %	361	620	5280	5280	-
Sub plot					
C. N levels					
N_0 : 0 Kg ha^{-1}	2510	5021	63592	31429	1.97
N_1 : 50 Kg ha^{-1}	3537	6588	87349	54603	2.66
N_2 :100 Kg ha^{-1}	3931	7455	97543	64220	2.91
N_3 :150 Kg ha^{-1}	4074	7805	101497	67585	2.98
SE (m) ±	103		1720	1720	-
CD at 5 %	302	493	5024	5024	-
Interactions	**Interaction effects of D X V, D X N, V X N and D X V X N were found to be NS**				
GM	**3514**	**6718**	**87496**	**54460**	**2.63**

Effect of nitrogen levels

Yield attributes (Table 1) viz., length of cob (cm), weight of cob (g), girth of cob (cm), number of grains per cob and test weight (g) significantly influenced by application various nitrogen levels. Significantly greater yield attributes were recorded with application of nitrogen (N_3) @ 150 Kg N ha^{-1} over the (N_1) @ 50 Kg N ha^{-1} and (N_0) @ 0 Kg N ha^{-1}. However, application of (N_3) @ 150 Kg ha^{-1} was at par with (N_2) @ 100 Kg N ha^{-1} in case of weight of cob and number of grains. Significantly lowest weight of cob and number of grains was recorded with application 0 Kg N ha^{-1} *i.e.* control treatment. Significantly highest grain and fodder yield was noticed in (N_3) @ 150 Kg N ha^{-1} (4074 and 7805 Kg ha^{-1}) over (N_1) @ 50 Kg N ha^{-1} (3537 and 6588Kg ha^{-1}), and (N_0) @ 0 Kg N ha^{-1} (2510 and 5021Kg ha^{-1}), respectively. Result showed that with increased levels of nitrogen increases grain yield of maize. Similar findings were also reported by Singh (2001) (Table 2). Significantly highest gross monetary return was recorded in (N_3) @ 150 Kg N ha^{-1} (Rs. 101497 ha^{-1}) over control treatments *i.e.* application of (N_1) @ 50 Kg N ha^{-1} (Rs. 87349 ha^{-1}) and (N_0) @ 0 Kg N ha^{-1} (Rs. 63592 ha^{-1}). Similar research trend was also found by Aashish *et al.* (2015). Significantly highest net monetary return was observed with application of (N_3) @ 150 Kg N ha^{-1} (67585 Rs ha^{-1}) over treatments (N_1) @ 50 Kg N ha^{-1} (Rs. 54603 ha^{-1}) and (N_0) @ 0 Kg N ha^{-1} (Rs. 31429 ha^{-1}), respectively. Highest benefit cost ratio was recorded with treatment application of 150 Kg N ha^{-1} (2.98) followed by treatments 100 Kg N ha^{-1} (2.91), 50 Kg N ha^{-1} (2.66) and control (1.97), respectively (Table 2).

Effect of interactions

The interaction effects among the no de-topping and de-topping practice, variety and various nitrogen levels on yield attributes, grain yield and fodder yield per ha gross and net monetary returns per ha was found to be non-significant (Table 1 and 2).

Conclusions

Treatment of no de-topping recorded significantly maximum grain yield, gross monetary returns per ha, net monetary returns per ha and minimum fodder yield per ha as compared to de-topping after 15 days of tasseling. Among the grain and fodder type variety, Pioneer-3396 recorded significantly maximum grain yield, gross and net monetary returns per ha and minimum fodder yield per ha as compared to fodder variety African tall. Graded levels of N fertilizer *i.e.*150 Kg N ha^{-1} recorded significantly maximum grain yield, fodder yield, gross and net monetary returns per ha, respectively as compared to lower levels of nitrogen *i.e.* 100, 50 and 0 Kg N ha^{-1}, respectively.

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Evaluation of Ecofriendly Approaches for Management of Gram Pod Borer *H.armigera* in Chickpea

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Abstract: The present investigation carried out at Pulses Research Unit for the Rabi season 2018-19 with 9 treatments viz. Azadirechtin 300ppm, *HaNPV*($2X10^{9}$), Bt127, Delfin, Mahastra, *B.bassiana, Metarhizium anisopliae*, chlorantriniliprole 18.5 sc and untreated plot considered as a control.The observation recorded at 50% flowering and pod filling stage at seven and fourteen days after spraying. Chlorantriniliprole found best treatments, recorded least larval population. While the treatments found at par were azadirechtin (0.99 larva/plant) and Hanpv (1.14 larva /plant).

The same treatment evaluated for percent pod damage at harvest and yield (Qui/ha).The best treatments found was chlorantrinilprole 18.5 sc recorded a percent pod damage of 1.13 percent and yield 32.21 qui/ha. While the next better treatment for percent pod damage by *H.armigera* were found *HaNPV* and *B.bassiana* recorded 1.45 per cent and 1.97 percent pod damage. In respect of yield, the best treatment found were *HaNPV* and azadirechtin treated plots recorded of 33.99 qui/ha and 31.48 qui/ha yield, respectively.

Keywords: *H.armigera, HaNPV*

Introduction

The pod borer *H.armigera* (Hubner) (Lepidoptera-Noctuidea) Is responsible for causing damage up to 90% in chickpea due to it's regular occurrence from the vegetative growth to pod formation stage. Sustainable approaches to reduce the incidence of pod borer and achieve sustainability in chickpea production systems through the adoption of an integrated approach (Patil *et.al*, 2017). Pod borer outbreaks, causing 10-80% yield losses(Yelshetti,1999) result from the direct reduction in crop yield and cost of monitoring and controlling insect pests. Particularly the cost of insecticides (ICRISAT,1992).The first second and third instar larvae initially feed on the foliage of chickpea and a few other buds of cotton pigeonpea etc. larvae shift from foliar feeder to developing seeds and fruits as larval instar development progresses (Reed and Pawar,1982).

Considering the importance of insect pest, *H.armigera* in chickpea, the present experiment planned for evaluation of ecofriendly approaches for management of gram pod borer *H.armigera* in chickpea. The main objective of the study is to reduce cost of insecticides. And to made available eco-friendly options such as botanical, and biopesticides. So that use of insecticides should be optimize.

Material and Method

The present investigation revealed the eco-friendly approaches for management of gram pod borer *H.armigera* in chickpea. The present investigation was carried out in the Rabi season of 2018-19 on the field of Pulses Research Unit, Dr. PDKV, Akola, Maharashtra. The host plant selected was chickpea evaluated with nine treatments viz.Azadirechtin 300ppm, *HaNPV* ($2X10^{9}$), *Bt*127, Delfin, Mahastra, *B.bassiana, Metarhizium anisopliae*, chlorantriniliprole 18.5 sc and untreated plot considered as a control, evaluated against *H.armigera*. Spraying was done at the 50% flowering and pod filling stage and observations recorded at seven and fourteen days after spraying (Larva/five plant). Similarly the observations recorded to asses the effect of different treatment on per cent pod damage at the time of harvet (five plant per plot average workout), at the time of harvest and yield recorded in all the treatment.

Results

Effect of different treatments in chickpea at 50% flowering on *H.armigera*

The data given in Table 1 reveals that, spray applied in chickpea at 50 per cent flowering and observations recorded 7 days after spray, the plots treated with chlorantriniliprole 18.5 sc and *HaNPV* 250LE was free from the larval population of *H.armigera* and both these treatment were at par with each other

The other treatment such as azadirechtin, Bt, *B.bassiana*, delfin, Mahastra, *M. anisopliae* recorded the larval population 0.06, 0.2, 0.2, 0.2, 0.2, 0.26 per cent respectively. While untreated plot recorded the higher no. of larva/ plant (0.33).

Observations recorded fourteen days after spray at the time of 50 per cent flowering found that the chlorantrinilliprole 18.5 sc was superior treatment and free from larval population. The next effective treatment for controlling *H.armigera* larva were azadirechtin and *HaNPV* recorded a larval population of 0.06 larva/plant. Other treatment recorded a larval population of 0.13, 0.2, 0.2, 0.26 and 0.33 larva/ plant were Mahastra, *B.bassiana*, Bt, *M.anisopliae*, and delfin. While the higher larval population recorded in untreated plot (1.37).

The data given in Table-1, reveals that spray applied at pod filling stage, and observations recorded 7 days after spray the larval population of *H.armigera* recorded in the treatment of chlorantrinilliprole 18.5 sc and *Hanpv* were free from damage, and found statistically similar, The other treatment such as azadirechtin, Mahastra, Bt, delfin, *M. anisopliae* and *B.bassiana* recorded the larval population 0.06, 0.2, 0.2, 0.26 and 0.33 larva/ plant respectively. While untreated plot recorded the higher larval population of 0.46 larva/plant .

Observations recorded fourteen days after spray at the time of pod filling stage found that the chlorantrinilliprole 18.5 sc and *Hanpv* were free from *H.armigera* damage and found at par with other and superior over rest of the treatment. The next effective treatment were azadirechtin recorded a larval population of 0.06 larva/five plant each. The other treatments recorded larval population of 0.2, 0.2, 0.26, 0.26 and 0.26 larva/five plants respectively were *Bt*, Mahastra, delfin, *B,bassiana*, *M.anisopliae*. While the highest population i.e.0.66 larva/five plant recorded in untreated plot.

The data presented in Table 2 indicate that, the effect of different treatment on per cent pod damage at harvest, indicate that chlorantrinilliprole 18.5 sc (1.13 per cent) recorded lower per cent pod damage and found superior over all other treatment, While *Hanpv*, *B. bassiana*, Bt, Mahastra, *M.anisopliae*, azadirechtin and delfin recorded a per cent pod damage are 1.45, 1.97, 2.04, 2.06, 2.59, 2.64 and 2.85 per cent, respectively. Higher per cent pod damage recorded in the untreated plot i.e. 5.00 per cent.

The yield recorded in different treatment, indicate that the highest yield recorded in the treatment of Hanpv 3399 kg/ha which is at par with chlorantrinilliprole 18 sc (3221 Kg/ha), both these treatment found statistically similar. The other treatment followed by were azadirechtin (3148 kg/ha), The treatment of *M.anisopliae* (2915 kg/ha), mahastra (2806 Kg/ha) and *B.bassiana* (2704 Kg/ha) were found at par with each other. The lower yield recorded in the treatment of untreated plot (2590 kg/ha) , Bt (2576 kg/ha) and delfin (2543 kg/ha).

Cowgil and Bhagwat (1996) reported HaNPV was more effective in killing *H.armigera* to succeptible genotypes of chickpea. Agale *et. al.*,(2017) evaluated varied doses of biopesticide. Among those neem seed powder and HaNPV recorded maximum per cent mortality. NSKE powder 72 hours after application causes 100 per cent mortality. NSKE found most effective in larval reduction and pod damage, Prasad and Roy (2011). This finding confirmed by Kulkarni *et al.*(2005), Ali *et al.*, (2008) and Kale and Men (2008) reported *M. anisopliae*, neem seed powder and their combinations are most effective in reducing *H.armigera* damage.

Table 1 : Effect of different insecticide treatment in chickpea on *H.armigera*.

Sr.	Treatment Details	Flowering Spray		Pod filling Spray	
		7[th] DAS	14[th] DAS	7[th] DAS	14[th] DAS
T1	**Azadirechtin 300 ppm**	0.06 (0.84) (0.84)	0.06 (0.84)	0.06 (0.84)	0.06 (0.84)
T2	**Hanpv(2x10^{9}POBs/ml) 250LE/ha**	0 (0.7)	0.06 (0.84)	0.0 (0.7)	0.0 (0.7)
T3	**B.thuringenesisK127 Sc@ 3ml/lit**	0.2 (1.14)	0.2 (1.14)	0.26 (1.20)	0.2 (1.14)
T4	**Delfin**	0.2 (1.14)	0.33 (1.25)	0.33 (1.25)	0.26 (1.20)
T5	**Mahastra 4gm/lit**	0.2 (1.14)	0.13 (0.99)	0.2 (1.14)	0.2 (1.14)
T6	***Beauverlabassiana* @ 5 g/lit**	0.2 (1.14)	0.2 (1.14)	0.46 (1.37)	0.26 (1.20)
T7	***M. anisopliae* @ 5 gm/lit**	0.26 (1.20)	0.26 (1.20)	0.33 (1.25)	0.26 (1.20)

Sr.	Treatment Details	Flowering Spray		Pod filling Spray	
		7^{th} DAS	14^{th} DAS	7^{th} DAS	14^{th} DAS
T8	**Chlorantriniliprole18.5sc@ 2.5 ml/lit**	0.0 (0.70)	0.0 (0.70)	0.0 (0.70)	0.0 (0.70)
T9	**Untreated check**	0.33 (1.25)	0.46 (1.37)	0.6 (1.46)	0.66 (1.51)
	SE(m)+_	0.04	0.04	0.04	0.05
	CD at 5%	0.09	0.09	0.089	0.107
	CV%	12.3	13.37	11.65	13.35

Table 2 : Effect of different treatment at per cent pod damage and yield in chickpea on *H.armigera.*

Treatment	Treatment Detail	Per cent Pod damage at harvest	Yield Qui/ha
T1	**Azadirachtin 300 ppm @10 ml/lit**	2.64	3148
T2	**Hanpv(2x10^9) 1ml/lit**	1.45	3399
T3	**Bacillus thuringenesis K. 127 Sc@3ml/lit**	2.04	2576
T4	**Delfin 1g/lit**	2.85	2543
T5	**Mahastra @4 gm/lit**	2.06	2806
T6	**Beauveriabassiana @ 5 g/lit**	1.97	2704
T7	**Metarhiiziumanisopliae @ 5 gm/lit**	2.59	2915
T8	**Chlorantriniliprole 18.5 sc @ 2.5 ml/lit**	1.13	3221
T9	**Untreated check**	5.0	2590
	SE(m)+_	0.10	104.8
	CD at 5%	0.29	222.2
	CV%	9.26	10.92

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Performance of Leafy Vegetables under Organic and Integrated Nutrient Management

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Abstract: A field experiment was carried out at Agronomy Farm, Dr. PDKV, Akola during *rabi* season of 2017-18 on clayey soil. The experiment was laid out in factorial randomized block design with nine treatment combinations and four replications. Treatments consist of three nitrogen sources viz., 100% N through urea, 50% N through FYM + 50% N through urea and 50% N through FYM + 50% N through Vermicompost + Biofertilizers and three vegetables viz., Coriander, Fenugreek and Spinach. The growth characters of all vegetables were significantly higher with the application of 50% N through FYM + 50% N through urea followed by 50% N through FYM + 50% N through Vermicompost + Biofertilizers. Maximum green biomass yield of all vegetables was recorded with INM application of 50% N through FYM + 50% N through urea followed by application of 50% N through FYM + 50% N through Vermicompost + Biofertilizers.

Key words: INM, Urea, FYM, Vermicompost, Vegetable, Biomass

Introduction

Vegetables constitute an important item for providing essential health promoting and protective substances; hence vegetables are also called as health capsules. Vegetables are rich source of important minerals (iron and calcium), vitamins (A, C, and riboflavin) and fiber sources with lower calories. Adequate vegetable consumption can be protective some chronic diseases such as diabetes, cancer, obesity, metabolic syndrome, cardiovascular diseases, as well as improve risk factors related with these diseases. India is a second largest producer of vegetables after China in the world.

Several vegetables are grown in India out of these spinach, coriander, fenugreek are important and regular ones. Coriander *(Coriandrum sativum* L.*)* seeds as well as fresh green leaves are utilized in many culinary preparations. Fenugreek (*Trigonella foenum-graecum*) is considered to be poor people's nutritive vegetable. It is cheap to buy and easy to grow in kitchen garden and in field and can be cooked quickly. Among the leafy vegetables, Indian Spinach *(Beta vulgaris.* L.) is one of the most important leafy vegetable consumed all over the country. It is native of indo-chinese region.

Excessive use of chemical fertilizers in an imbalance proportion has created a lot of problems pertaining to hazardous residual effects on soil and succeeding crops simultaneously. It also creates a multiple nutrients deficiency, deteriorating soil structure and texture along-with undesirable crop yield. The gap between the nutrient demand and supply cannot be bridged by fertilizes alone. It can be filled only through integrated nutrient management (INM) which refers to appropriate combination of mineral fertilizers, organic manures, compost, N-fixing crops and micro-organisms (FAO, 1995). Recently, increased attention has been devoted to utilization of organic manures for increasing vegetables production. The INM approach therefore, could be a rational way to increase yield and profit from any crop. INM has spin offs as well. The most crucial is reduces the incidence of disease and pest attacks (Mirchandani and Mirchandani, 2005). Increasing resistance through efficient nutrition programmes can thus reduce the application of harmful and expensive pesticides and make farming more profitable, sustainable and environment friendly.

Objective

The gap between the nutrient demand and supply cannot be bridged by fertilizes alone. It can be filled only through integrated nutrient management (INM) which refers to appropriate combination of mineral fertilizers, organic manures, compost, N-fixing crops and micro-organisms (FAO, 1995). Now a day, the chemical fertilizers are very costly. To apply these chemical fertilizers effectively in right manner, lot of time and labour are requiring which ultimately results into increase in the cost of production. Considering the all facts, the present investigation is therefore planned to explore efficient organic source from available resources improving possibilities of effective nutrient management in leafy vegetables to get sustainable yield and soil health. Keeping in view the study was undertaken during year 2017-2018 with the objectives to study the growth, yield and quality of leafy vegetables.

Material and Methods

The field experiment was conducted in the experiment field of Department of Agronomy, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the academic year 2017.The experiment was laid out in factorial randomized block design with nine treatment combinations and four replications. Treatments consist of three nitrogen sources viz., 100% N through urea, 50% N through FYM + 50% N through urea and 50% N through FYM + 50% N through vermicompost + Biofertilizers and three vegetables viz., coriander, fenugreek and spinach. The gross and net plot size 3 m X 3m and 2.7m X 2.7m respectively. Fertilizers and manures are applied as per recommended fertilizer dose.

Result and Discussion

Plant Height (cm)

The yield attributes plant height, number of leaves per plant, leaf area per plant, dry matter per plant and green biomass is recorded in table No. 1. All these observations recorded significant influence due to various nitrogen sources at all stages of the crop growth.

Table 1: Growth and Yield of leafy vegetables as influenced by various treatments

Treatments	Plant height (cm)	No. of leaves	Leaf area (cm^2)	Dry matter (g)	Green Biomass kg ha^{-1}
Factor A (Nitrogen sources)					
N_1 - 100% N through urea	21.17	26.08	55.47	8.74	9984
N_2 - 50% N through FYM + 50% N through Urea	25.83	30.75	56.83	9.53	14188
N_3 - 50% N through FYM + 50% N through Vermicompost + Biofertilizers	23.83	27.00	55.71	9.36	12574
SE(m)±	0.67	0.69	0.30	0.21	415
CD (P=0.05)	1.95	2.02	0.86	0.60	1210
Factor B (Vegetables)					
V_1 - Coriander	14.08	40.58	8.24	6.90	7500
V_2 - Fenugreek	25.97	29.50	40.43	8.96	10253
V_3 - Spinach	30.78	13.75	119.35	11.77	18993
SE(m)±	0.67	0.69	0.30	0.21	415
CD (P=0.05)	1.95	2.02	0.86	0.60	1210
Interaction (N x V)					
SE(m)±	1.16	1.20	0.51	0.36	718
CD (P=0.05)	NS	NS	NS	NS	NS
GM	23.61	27.94	56.00	9.21	12249

Significantly highest plant height (25.83 cm) was recorded, with the application of 50% N through FYM + 50% N through urea from initial to harvest. Among vegetables Spinach recorded significantly highest plant height (30.78 cm) over Fenugreek (25.97 cm) and Corriander (14.08 cm) at the time of harvesting. These observations showed significant differences due to different species characters. Interaction effect between nitrogen nitrogen sources and vegetable regarding plant height was found non significant.

Pronounced influence of inorganic fertilizers in combination with organic manures might be due optimum supply of nutrient particularly nitrogen. Impact of combined application of organic and inorganic nutrient on growth parameters might be due to increased assimilation of protoplasm resulting in greater cell division, formation of more tissues and vigor of plant. Similar results were obtained by Vitwel and Kanaujia (2013) who revealed that the application of 50% NPK + 50% FYM + Biofertilizers recorded maximum plant height in carrot. Rani *et al.* (2006) reported that application of neem cake and castor cake in combination with recommended half dose of nitrogen, phosphorus and potassium resulted maximum growth characters in carrots.

Number of leaves

Data pertaining to number of leaves was significantly influenced due to various nitrogen sources on plant growth. Among three Nitrogen sources significantly highest number of leaves was recorded with the application of 50% N through FYM + 50% N through Urea which was found significantly superior over application of 100% N through urea. Coriander produced a maximum leaf which was statistically superior over Fenugreek and Spinach at harvest. None of the interaction was found to be significant in respect to number of leaves per plant at harvest.

The production of maximum number of leaves might be due to higher metabolic activity because of optimum N supply resulting in higher production of Carbohydrates and Phytoharmones. These results are in line with Sentiyangla *et al.* (2010) who reported significant increase in number of leaves in radish, when applied integrated application of chemical fertilizers, organic manures and biofertilizers (50% NPK + 50% FYM + biofertilizers).

Leaf Area^{-1} (cm^2)

The leaf area plant^{-1} difference as among the nitrogen sources was significant at all stages of crop growth. Significantly maximum leaf area was observed with the application of 50% N through FYM + 50% N through urea which was superior over all treatments i.e. application of 50% N through FYM + 50% N through Vermicompost + Biofertilizers and 100% N through urea. It was observed that spinach has maximum leaf area than Fenugreek and Coriander at all the growth stages of crops. Interaction effect among nitrogen sources and vegetables was found to be non significant at all growth stages of crop in respect of leaf area plant^{-1}.

The increase in leaf area might be due to application of integrated nutrient supply enhances availability of nutrient in soil, reflected as in increase of leaf area. These results are in accordance with Sunanda *et al.* (2014) concluded that maximum leaf area was obtained in 75% N + RD PK + FYM 75 t ha^{-1} + Rhizobium 1.5 t ha^{-1} + Azospirilum 5 kg ha^{-1} + PSB 5 kg ha^{-1} in Kasurimethi.

Dry weight (g)

Dry weight per plant increased significantly and showed differences in dry weight of plant among various treatments. Maximum dry weight was noted with 50% N through FYM + 50% N through urea at 15 DAS. However, 50% N through FYM + 50% N through urea were found at par with 50% N through FYM + 50% N through vermicompost + Biofertilizers. The results are in close agreement with Sunanda *et al.* (2014) maximum total dry weight plant^{-1} was noticed in 75% N + RD PK + 75 t ha^{-1} FYM + Rhizobium 1.5kg ha^{-1} + Azospirillum 1.5 kg ha^{-1} + PSB 5 kg ha^{-1} in Kasurimethi. Spinach has recorded maximum dry weight plant^{-1} than Fenugreek and Coriander at all stages of growth from initial to at harvest. Interaction was not found significant among all treatment combinations.

Dry matter production and its partioning towards reproductive parts is an important yield attributing character. It is a basic vegetative phase is essential for the development of reproductive parts. Increased dry weight with INM could be due to application of balanced nutrients in integrated manner which promotes photosynthetic activity and transport of photosynthetic from source to sink which resulted in better plant growth.

Green biomass (kg ha^{-1})

Green biomass yield gets significantly differed due to various sources of nutrients. Highest green biomass yield was obtained with the application of 50% N through FYM + 50% N through urea which is followed by application of 50% N through FYM + 50% N through Vermicompost + Biofertilizers. The least biomass yield was obtained in 100% N through urea. In vegetables maximum yield was obtained in Spinach than Fenugreek and Coriander at harvest. Interaction effect was non-significant in respect to biomass.

Increase in dry matter production and its partitioning into different plant parts was might be due to due to application of urea and FYM in integrated manner. Similarly, chumyani*et al.* (2012) recorded in Tomato and Vimera *et al.* (2012) noted in king Chilli.

Conclusion

Experimental results revealed that growth characters i.e. plant height, number of leaves, number of branches, leaf area per plant and dry matter of all vegetables were significantly higher with the application of 50% N through FYM + 50% N through urea followed by 50% N through FYM + 50% N through Vermicompost + Biofertilizers. Maximum green biomass yield of all vegetables was recorded with application of 50% N through FYM + 50% N through urea followed by application of 50% N through FYM + 50% N through Vermicompost + Biofertilizers.

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Sweet Sorghum Varietal Line's Reaction to Shoot Fly, *Atherigona soccata* in *Kharif* Sorghum

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Abstract: In kharif 2019, 15sweet sorghum lines along with seven checks including four national checks were evaluated in randomized block design for their resistance to particularly shoot fly, *Atherigona soccata,* stem borer and aphid at Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif*. In each entry plant population was counted at 12 days after emergence (DAE). Observations on eggs per five plants and dead hearts due to shoot fly were recorded by counting total number of plants and plants showing dead hearts due to shoot fly in each entry at 28 DAE.

Lowest i.e. 1.00 score, glossy seedlings recorded in resistant checks IS 18551; among the test lines, the line SPV2692 (DRT 7K × RSSV 167) and resistant check IS 2205 scored 1.33 glossiness. Shoot fly eggs noted on five plans in each line was in the range 7.00 to 15.67; the least number of eggs were on test line SPV2692 (DRT 7K × RSSV 167) followed on resistant lines IS 2205 and IS 18551; and highest on check CSH 22 SS followed with 15.33 on susceptible check Swarna, Among the test lines, the lines viz., SPV2530 (NSSV 259 x RSSV 24), SPV2692 (DRT 7K × RSSV 167) and SPV2693 (RSSV 267 × RSSV 167) were statistically similar to resistant check.

Significant differences in dead hearts were recorded with lowest i.e. 20.77 % dead hearts in check entry IS 2205 (ch) 21 days after emergence and these dead hearts were on par dead with 22.40 in SPV2692 (DRT 7K × RSSV 167), 29.12%IS 18551, 30.75% in CSV 19 SS, 33.49% in SPV2693 (RSSV 267 × RSSV 167), 22.40% in SPV2692 (DRT 7K × RSSV 167) and 39.55% in SPV2530 (NSSV 259 x RSSV 24). The check entries IS 2205 recorded lowest dead hearts i.e., 23.47 % followed by 30.41 % dead hearts in test line SPV2692 (DRT 7K × RSSV 167) and 32.89 per cent another check IS 18551 28 DAE. However, lowest dead hearts were on par to dead hearts in earlier mentioned lines and in test lines SPV2693 (RSSV 267 × RSSV 167) 38.38%), SPV2530 (NSSV 259 x RSSV 24) (43.78%) and in check CSV 19 SS (34.80%). Maximum dead hearts were noted in CSH 22 SS with 87.95 followed with 83.30 and 82.94 per cent, respectively in susceptible check Swarna and SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1].

Keywords: Sweet sorghum, Sorghum bicolor, *Atherigona soccata*, hybrid.

Introduction

Being a most important cereal crops, Sorghum (*Sorghum bicolor*) is cultivated in Africa, Asia, United States of America, Australia and Latin America. Sorghum is grown extensively for food, feed, fodder, forage and fuel in the semi-arid tropics (SAT) of Asia, Africa, the Americas and Australia. It's importance after wheat, maize, rice and barley is because of its good adaptation to a wide range of ecological conditions, low input cultivation and diverse uses (Aruna *et al.* 2011). In India, it is grown on 6.18 million ha with annual production of 5.28 million tones and productivity 845.4 kg/ha in *kharif* and 674.7 kg/ha in *rabi* season (FAO, 2014). Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh and Rajasthan are the major states gaining the sorghum. In Maharashtra, it is grown on an area 36.78 lakh hectares with a production 31.93 lakh tones with a productivity of 868 Kg/ha. In Vidarbha, it is grown on an area of 2.62 lakh hectare in *kharif* with a production 2.47 lakh tones and with a productivity 943 kg/ha. Insect pests are the major biotic constraints for production and productivity of sorghum causing economic losses over US$1 billion annually in the SAT. The large number of pests has been reported on sorghum crop in Maharashtra, out of which very few have economic status, Shoot fly, stem borer, midge fly, shoot bug are major. Other important pests are armyworm, aphids, surface grasshopper, delphacids, ear head caterpillar etc. the insect pests are the major production constraints in sorghum reports Reddy and Devis (1979).

Almost 150 insect species have been reported as pest on sorghum out of which 22 are of potential economic significance. Among these, shoot fly (*Atherigona soccata*) is a major grain yield limiting factor that causes damage under delayed sowings in rainy season. Shoot fly infestation decreases plant stand, and also causes severe losses in grain and fodder yield. Increase in shoot fly dead hearts by 1 % results in a loss of 143 kg grain yield/ha, and an overall loss of 90–100 % was reported under delayed sowings (Chundurwar and Karanjkar 1979; Dhaliwal *et al.* 2004). The yield loss due to shoot fly has been estimated to be over 274 million US$ (Sharma 2006). In Maharashtra, jowar shoot fly is one of the major pests of sorghum causing dead hearts in early seedling stage, reducing plant population thereby causing heavy yield losses up to 75.60% in grain and 68.90% of fodder (Khandare et al. 2013). Some of plant attributes of seedlings are associated with shoot fly attack. Glossy leaves possibly affect the quality of light reflected from leaves and influence the orientation of shoot flies towards their host plant. Shoot fly resistant lines have rapid plant growth, greater seedling height and hardness and have longer stems. Rapid growth of seedlings may retard the first instar larvae from reaching the growing tip. In contrast, slow growth due to poor seedling vigour, low fertility or environmental stress increases shoot fly incidence (Taneja and Leuschner 1985; Patel and Sukhani 1990).The early-sown sorghum crop escapes from shoot fly damage but in most cases the late-sown crop is affected. Shoot fly infestation is high when sorghum sowings are spread over a period of time due to defective rainfall distribution which is common in the recent past in the state. Early sowing is not for all time practicable as the sowing window is short in rainfed situations and there exists a competition with other crops for sowing. The shoot fly management strategies such as agronomic practices, natural enemies, synthetic insecticides and host plant resistance have been employed for minimizing the losses by the pest. Host plant resistance (HPR) can play a most important role in putting down the extent of losses and is companionable with other tactics of pest management, including the use of natural enemies and chemical control. The HPR can be exploited as one of the most effective means of keeping insect pests below the economic threshold levels (Sharma 1985; Mohammed et al. 2015).The Sorghum Research Unit contributed for development and screening technique for selecting the sources of resistance against shoot fly. The objective of this study is to identify sweet sorghum hybrids and varietal lines with certain levels of shoot fly resistance and also to screen the lines for other pests like stem borer, aphids, fall armyworm and shoot bug.

Materials and Methods

The trial was sown in randomized block design having 15 sweet sorghum varietal lines alongwith seven national and local checks. Plant population in each entry was counted at 12 days after emergence. Seedling glossiness score scored on a 1 to 5 scale 12 DAE, where 1 = most glossy and 5 = non-glossy (Sharma et al., 1997) and seedling vigour score scored on a 1 to 5 scale 12 DAE, where 1 = most vigorous and 5=least vigorous (Sharma et al., 1997). Observations on shoot fly eggs were noted 14 DAE and dead hearts due to shoot fly were recorded by counting total plants and plant showing dead hearts due to shoot fly in each entry at 21st and 28th days after emergence and shoot fly dead hearts percentage was calculated. Stem borer leaf injury rating in the scale 1 to 9 was recorded at 35 DAE. The aphid leaf damage and shoot bug damage were assessed at milk stage in the scale 1.00 to 9.0. Stem borer dead hearts were observed at 45 days after emergence. The fall armyworm score in the scale 1-9 was noted at panicle emergence. The data on shoot fly dead hearts and stem borer dead hearts were statistically analyzed after appropriate transformation.

Results and Discussion

Seedling glossiness: Seedling glossiness in the scale 1-5 scale was ranged from 1.00 to 5.00 (Table 1); lowest i.e. 1.00 score, glossy seedlings in resistant checks IS 18551; among the test lines, the line SPV2692 (DRT 7K × RSSV 167) and resistant check IS 2205 scored 1.33 glossiness. Maximum score (5.00) i.e. very less glossy seedlings was in check CSH 22 SS followed with 4.67 in test line SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1] susceptible check Swarna had score 4.33. The expression of glossiness in seedlings is an important trait for shoot fly resistance in sorghum (Agarwal and House 1982). Dhillon et al. (2005) studied 12 sorghum genotypes and found that leaf glossiness of ICSV-705, ICSV-700, ICSV-708, SFCR-151, SFCR-125 and ICSV-91011 was comparable to resistant check, IS-18551; whereas, genotypes ICSV-745, CS-3541, MR-750 and Swarna were observed to be non-glossy. Omori et al. (1993) also concluded that glossy seedling expression could be used as a simple and reliable criterion for resistance, which supports the present findings. Sonalkar and Pagire (2017) reported more than 3.0 glossiness score in test varieties. Prasad et al., (2014) observed seedling glossiness score range 1.8 to 4.6 with low values for resistant checks. Sonalkar et al. (2019) observed glossy seedlings in seedlings resistant lines and non-glossy seedlings in susceptible lines for shoot fly.

Seedling vigor: Seedling vigour expressed in scale 1-5 and range was 2.33 to 4.67 (Table 1); vigorous seedlings i.e. low score was for the test line SPV2602 [(SPV 1871 × SSV 74)-5-2-1-1-1] followed with 2.67 for resistant check IS 18551and test line SPV2692 (DRT 7K × RSSV 167). High score (4.67) was for susceptible check DJ 6514 followed with 4.00 susceptible check Swarna and test line SPV2699 [K-18-SSR 9-(SPV 1616 × SSV 74)-3-1-1-2-1]. Significance of early seedling vigour in sorghum for shoot fly resistance was studied by Chamarthi et al. (2011) and observed significantly high seedling vigour for resistant lines compared to susceptible lines. Shoot fly resistant lines showed rapid plant growth (Mote et al. 1986), similarly, Mate et al. (1988) reported rapid plant growth in resistant lines. Sonalkar et al. (2019) noted high vigour (low score) in resistant lines.

Shoot fly eggs: Shoot fly eggs noted on five plans in each line was in the range 7.00 to 15.67 (Table 1); the least number of eggs were on test line SPV2692 (DRT 7K × RSSV 167) followed on resistant lines IS 2205 (7.33) and IS 18551 (8.00); and highest i.e. 15.67 on check CSH 22 SS followed with 15.33 on susceptible check Swarna, test lines SPV2601 [(SPV 1870 × SSV 74)-5-2-2-1-1] and SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1]. Among the test lines, the lines viz., SPV2530 (NSSV 259 x RSSV 24) (9.67), SPV2692 (DRT 7K × RSSV 167) (7.00) and SPV2693 (RSSV 267 × RSSV 167) (8.00) were statistically similar to resistant check.

Shoot fly dead hearts at 21 DAE: Significant differences in dead hearts were recorded with lowest i.e. 20.77 % dead hearts in check entry IS 2205 (ch) (Table 1, Fig 1) 21 days after emergence and these dead hearts were on par dead with 22.40 in SPV2692 (DRT 7K × RSSV 167), 29.12% IS 18551, 30.75% in CSV 19 SS, 33.49% in SPV2693 (RSSV 267 × RSSV 167), 22.40% in SPV2692 (DRT 7K × RSSV 167) and 39.55% in SPV2530 (NSSV 259 x RSSV 24). Highest per cent dead hearts were in CSH 22 SS (77.13%) followed in susceptible check Swarna (76.44%). These findings are confirmed by findings by Khandare et *al.* (2013) who noted significantly minimum percentage shoot fly dead hearts 21 DAE in resistant check IS-18551. Similarly, Sonalkar et al. (2019) reports low shoot fly dead hearts in IS18551 and IS 2205.

Shoot fly dead hearts at 28 DAE: The check entries IS2205 recorded lowest dead hearts i.e., 23.47 % followed by 30.41 % dead hearts in test line SPV2692 (DRT 7K × RSSV 167) and 32.89 per cent another check IS 18551 (Table 1, Fig 1). However, lowest dead hearts were on par to dead hearts in earlier mentioned lines and in test lines SPV2693 (RSSV 267 × RSSV 167) 38.38%), SPV2530 (NSSV 259 x RSSV 24) (43.78%) and in check CSV 19 SS (34.80%). Maximum dead hearts were noted in CSH 22 SS with 87.95 followed with 83.30 and 82.94 per cent, respectively in susceptible check Swarna and SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1]. In the present findings, minimum dead hearts were observed in IS-2205 (23.47%) followed with 30.41 % in test line SPV2692. Khandare et al. (2013) reported minimum dead hearts in IS-18551 (20.10 %) which was being significantly least than the dead hearts in test entries. Whereas, none of the test line observed on par dead hearts to dead hearts in resistant check (Sonalkar and Pagire, 2017, Sonalkar et al., 2019).

Table 1. Reaction of grain sweet sorghum lines to shoot fly kh 2019-20.

SR	Sorghum Entry	SGS 12 DAE (1-5)	SV 12 DAE (1-5)	SF eggs 14 DAE (/5 Pl.)		SF-DH 21 DAE (%)		SF-DH 28 DAE (%)	
				OV	TV*	OV	TV**	OV	TV**
1	SPV2529 [(NSSV 13 x IS 21890)-6-1-1 x Atlas]-1-2-1)]	3.33	3.33	14.00	3.74	63.25	51.49	71.71	57.46
2	SPV2530 (NSSV 259 x RSSV 24)	2.00	3.67	9.67	3.09	39.55	35.51	**43.78**	38.22
3	SPV2600 [(Honey × N 98 Tall)-1-1-1-1-1-1]	3.67	3.00	14.33	3.79	71.73	57.85	78.81	62.32
4	SPV2601 [(SPV 1870 × SSV 74)-5-2-2-1-1]	4.00	3.33	15.33	3.92	75.66	60.40	81.10	64.14
5	SPV2602 [(SPV 1871 × SSV 74)-5-2-1-1-1]	3.67	2.33	15.00	3.87	69.46	55.32	78.41	61.50
6	SPV2604 (ICSV 93046-1)	2.67	3.00	12.67	3.55	57.40	47.98	65.52	52.77
7	SPV2692 (DRT 7K × RSSV 167)	1.33	2.67	7.00	2.64	22.40	26.92	**30.41**	31.76
8	SPV2693 (RSSV 267 × RSSV 167)	2.33	3.33	8.00	2.82	33.49	33.30	**38.38**	36.59
9	SPV2694 [(SSV 84 × IS 21890)-1-1-1-2-1-1-1]	4.00	3.67	14.00	3.74	73.20	58.48	81.08	63.68
10	SPV2695 [(SSV 84 × EC 582508)-3-1-1-1-2-1-2-1-2]	3.33	3.67	12.33	3.50	53.89	44.79	64.63	50.93
11	SPV2696 [(SSV 84 × EC 582508)-4-1-1-1-2-1-1-1]	3.00	3.00	11.67	3.41	52.12	43.14	64.88	51.22
12	SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1]	4.67	3.00	15.33	3.91	75.79	61.02	82.94	65.76
13	SPV2698 [(SSV 1871 × SSV 74)-5-2-1-1-1-2]	3.67	3.33	14.33	3.79	70.62	56.37	77.58	61.56
14	SPV2699 [K-18-SSR 9-(SPV 1616 × SSV 74)-3-1-1-2-1]	3.67	4.00	13.67	3.67	66.44	53.24	73.15	59.09
15	SPV2700 [K-18-SSR 12 (RSCN 2103 × SSV 84)-2-1-2-1-1-1]	4.00	3.00	14.33	3.79	68.48	54.52	74.22	58.43
16	CSH 22 SS	5.00	3.00	15.67	3.96	77.13	62.20	87.95	69.98
17	CSV 19 SS	2.00	3.00	8.33	2.88	30.75	35.03	**34.80**	37.56
18	CSV 24SS	3.33	3.33	12.33	3.49	59.64	49.07	65.82	53.34
19	IS 18551	1.00	2.67	**8.00**	2.82	**29.12**	31.81	**32.89**	35.07
20	IS 2205	1.33	3.00	7.33	2.70	16.97	26.34	**23.46**	31.19
21	DJ 6514	4.00	4.67	15.00	3.87	73.04	57.29	79.62	61.68
22	Swarna	4.33	4.00	15.33	3.91	76.44	60.53	83.30	65.32
	CD at 5%				0.40		7.70		8.61
	CV (%)				6.94		9.68		9.83

Note: SGS, seedling glossiness score; SV, seedling vigour; SF-DH, shoot fly dead hearts; OV, original values; TV*, square root transformed values; TV**arc sine transformed values.

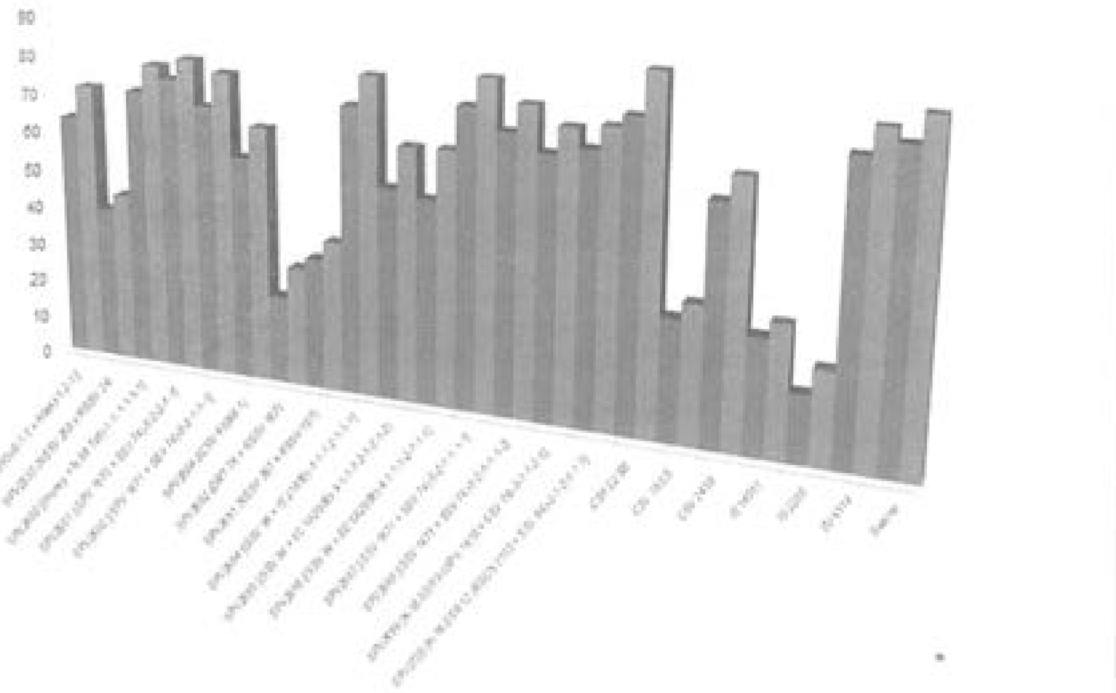

Fig. 1. Reaction of grain sweet sorghum lines to shoot fly kh 2019-20.

Stem borer leaf injury damage: Stem borer leaf injury damage was reorded in the damage scale 1 to 9.0. The damage score within the sorghum lines was ranged fro 1.00 to 2.67. The least damage was scored by IS 18551 (1.00) followed with 1.33 in check CSV 24SS; among the test lines, SPV2692 (DRT 7K × RSSV 167), SPV2695 [(SSV 84 × EC 582508)-3-1-1-1-2-1-2-1-2] and SPV2696 [(SSV 84 × EC 582508)-4-1-1-1-2-1-1-1] scored damage score 1.33 each.

Stem borer dead hearts: The stem borer dead heart damage within sorghum entries was significant 45 DAE (Table 2). However, significantly low dead heart damage was noted in line SPV2693 (RSSV 267 × RSSV 167) (0.00%) which was at par with dead hearts in test lines SPV2529 [(NSSV 13 x IS 21890)-6-1-1 x Atlas]-1-2-1)] (4.35%), SPV2530 (NSSV 259 x RSSV 24) (4.18%), SPV2601 [(SPV 1870 × SSV 74)-5-2-2-1-1] 1.52%), SPV2692 (DRT 7K × RSSV 167) (1.39%), SPV2696 [(SSV 84 × EC 582508)-4-1-1-1-2-1-1-1[(2.08%), SPV2699 [K-18-SSR 9-(SPV 1616 × SSV 74)-3-1-1-2-1] (3.19%,) check CSV 19 SS (1.15%,) IS 18551 (2.58%) and resistant check IS 2205 (3.67%). Highest dead hearts with 9.27 % were observed in susceptible line DJ 6514 followed with 8.25 in Swarna.

Aphid damage: The aphid damage was assessed in the damage scale 1.0 to 9.00 (Table 2). The aphid damage score was at low level ranging from 1.00 to 2.00.The sweet sorghum line SPV2602 [(SPV 1871 × SSV 74)-5-2-1-1-1] being scored least damage (1.00).

Shoot bug Damage: The shoot damage was assessed in the damage rating scale 1.00 to 9.00 (Table 2); the range of damage score within entries was 1.67 to 4.33; the least shoot bug damage (1.67) were for test lines SPV2602 [(SPV 1871 × SSV 74)-5-2-1-1-1] and SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1] and higher shoot bug damage was in test line SPV2600 [(Honey × N 98 Tall)-1-1-1-1-1-1].

Fall army worm damage: The fall army worm damage was expressed as damage scale 1.0 to 9.00 (Table 2); the damage score was in the range 1.67 to 2.67. The sweet sorghum lines viz., SPV2693 (RSSV 267 × RSSV 167), SPV2530 (NSSV 259 x RSSV 24) and SPV2695 [(SSV 84 × EC 582508)-3-1-1-1-2-1-2-1-2] expressed 1.67 damage score for fall armyworm.

Table 2. Reaction of sweet sorghum lines to major pests kh 2019.

SR	Sorghum Entry	SBLIR (1-9)	SB-DH 45 DAE (%)		Ah-DR (1-9)	ShB-DR (1-9)	FAW-DR (1-9)
			OV	TV*			
1	SPV2529 [(NSSV 13 x IS 21890)-6-1-1 x Atlas]-1-2-1)]	1.67	4.35	1.98	1.67	3.00	2.67
2	SPV2530 (NSSV 259 x RSSV 24)	1.67	4.18	1.96	1.67	2.33	1.67
3	SPV2600 [(Honey × N 98 Tall)-1-1-1-1-1-1]	2.33	5.63	2.45	1.67	4.33	3.00
4	SPV2601 [(SPV 1870 × SSV 74)-5-2-2-1-1]	2.00	1.52	1.22	1.67	2.33	2.33
5	SPV2602 [(SPV 1871 × SSV 74)-5-2-1-1-1]	1.67	3.81	2.07	1.00	1.67	1.67
6	SPV2604 (ICSV 93046-1)	2.33	6.79	2.64	2.00	2.33	2.67
7	SPV2692 (DRT 7K × RSSV 167)	1.33	1.39	1.19	1.33	2.00	2.33
8	SPV2693 (RSSV 267 × RSSV 167)	1.67	0.00	0.71	1.67	2.33	1.67
9	SPV2694 [(SSV 84 × IS 21890)-1-1-1-2-1-1-1]	2.00	4.53	2.03	2.00	2.67	2.67
10	SPV2695 [(SSV 84 × EC 582508)-3-1-1-1-2-1-2-1-2]	1.33	5.56	2.19	2.00	2.33	1.67
11	SPV2696 [(SSV 84 × EC 582508)-4-1-1-1-2-1-1-1]	1.33	2.08	1.34	1.33	2.33	1.67
12	SPV2697 [(SSV 1871 × SSV 74)-5-2-1-1-1-1]	2.33	7.14	2.72	1.67	1.67	2.33
13	SPV2698 [(SSV 1871 × SSV 74)-5-2-1-1-1-2]	1.67	4.17	2.16	1.67	2.33	2.33
14	SPV2699 [K-18-SSR 9-(SPV 1616 × SSV 74)-3-1-1-2-1]	2.00	3.19	1.76	1.33	2.00	2.00
15	SPV2700 [K-18-SSR 12 (RSCN 2103 × SSV 84)-2-1-2-1-1-1]	2.00	4.29	2.19	1.67	2.00	2.33
16	CSH 22 SS	2.33	6.80	2.67	1.33	1.67	2.00
17	CSV 19 SS	1.67	1.15	1.13	1.67	2.00	1.67
18	CSV 24SS	1.33	4.72	2.28	1.67	2.33	1.67
19	IS 18551	1.00	2.58	1.63	1.67	1.67	1.67
20	IS 2205	2.67	3.67	1.86	2.00	2.33	2.33
21	DJ 6514	2.67	9.27	3.12	1.67	1.67	2.00
22	Swarna	2.33	8.25	2.95	1.67	3.00	2.00
	CD at 5%			1.27			
	CV (%)			38.32			

Note: SBLIR, stemborer leaf injury rating; SB-DH, stem borer dead hearts; OV-Original values, TV*, x+0.5 square root transformed values; Ah-DR- Aphid-plant damage rating; ShB, shoot bug plant damage rating; FAW-DR-Fall army worm damage rating.

Conclusions

The dead hearts caused by shoot fly was up to 87.95 %; under scuh circumstances of high pest pressure the lines viz. SPV2692 (DRT 7K × RSSV 167) and SPV2693 (RSSV 267 × RSSV 167) are effective for shoot fly and stem borer. The damage by insect pests viz.,aphids, shoot bug, fall armyworm was not much hence the lines needs evaluate under high pest pressure for these pests.

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Life Stages and Management of Groundnut Bruchid *Caryedon serratus* (Olivier)

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Abstract: The present investigation on Life stages and Management of groundnut bruchid, *Caryedon serratus* was conducted in the laboratory of Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2019-20. The main objectives of this study were to study the biology and the management of groundnut bruchids. The bruchid population was multiplied under laboratory conditions at a temperature of 25±2°C and 70% relative humidity using the groundnut pods. Egg incubation period, grub period, pupal period, adult longevity and total life period were examined. For management study the experiment was laid out in Completely Randomised Design and comprises of nine treatments and replicated thrice. Freshly harvested and dried groundnut pods were used for experimentation. For each treatment, one kg pod was used. 100 ppm stock solution of each insecticide was prepared. Required dose of insecticides was taken from 100 ppm stock solution for pod and storage bag treatment. In some treatment pods were treated with insecticides, shade dried, packed in 1 kg capacity cloth bag. In other treatments storage bags were treated with insecticides, shade dried and filled with pods. Both treated pods filled in storage bags and treated bags filled with pods were kept in laboratory under room temperature for further observations.The average mean life period of male groundnut bruchid was 69 days and for female it was 76.50 days. The grub (damaging stage) period of *Caryedon serratus* was lasted for an average of 33 days. Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l kept the groundnut pod damage due to *Caryedon serratus* below 10% i.e 6.33% up to seventh month of the storage followed by pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l (9% pod damage). Kernel damage due to *C. serratus* from the treatment pod treated with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l was recorded below 10% i.e 4.33% after sixth month of storage followed by pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l recorded 6% kernel damage.

Keywords : *Arachis hypogaea*, *Caryedon serratus*, coleoptera, life stages, deltamethrin, emamectin benzoate, flubendiamide, spinosad.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of Leguminaceae family and it contains 48 to 50 % oil and 26 to 28 % protein (Sakhare et al., 2018). Groundnut as pods (unshelled form) and in kernels (shelled form) is stored by farmers, processors, seed agencies and other oil extraction units for about 6-9 months before final use. In India, storage losses of groundnut range between 10 and 15% (Swathi, 2016). The postharvest losses in groundnut caused by insect-pests, moulds and rodents vary from 10 to 25%. Among the pests, post harvest insect pests like groundnut bruchid, *Caryedon serratus* (Olivier) is a primary feeder (Bhogeesh et al., 2014). *C. serratus* causing approximately 17-47 per cent of the pods damage (Bhogeesh et al., 2014). *C. serratus* is regarded as the only species that can penetrate intact pods to infest kernels. Losses due to *C. serratus* vary from 19.0 to 60.0 percent. The grub of *C. serratus* bore into the seeds via small holes and feed on the embryo and the endosperm and final instar grub comes out for pupation through exit holes (Sakhare et al., 2018). This causes post harvest losses in stored groundnut which result in farmers fetch low marginal cost in spite of scope for achieving higher market price for the produce if stored for a little longer time. The losses are in term of qualitative and quantitative. Damage of groundnut bruchid resulted into poor germination of infested seeds and thereby reduces the seed quality. The egg, larval and pupal periods ranged from 3 to 9, 19 to 38, 9 to 34 days with an average of 6.25, 31.21, 26.55 days, respectively. The adult longevity and total life cycle ranged from 19 to 30 and 43 to 70 days with an average of 19.62 and 57.16 days, respectively (Sandeep et al., 2005).The knowledge of insect life stages provides information about the weak links of insect growth stages and their activity periods and sites which if targeted can ensure for effective management of any pest. Such knowledge can also be useful in synchronizing the timing of application of pest management tactics with weak-link or susceptible growth stage of insect; thus, ultimately would be helpful in reducing blind use and application intensity of pesticide (Arif et al., 2017). The use of insecticidal protestants is a common preventative measure to protect store grain from insect damage. Many of these insecticides are effective at relatively low dosage and provide long term protection, which can range from six to twelve months. Keeping this in view, a study was conducted on life stages and management of *C. serratus* on groundnut.

Materials and Methods

The experiment was undertaken in laboratory of Seed Technology Research Unit, Dr. PDKV Akola during July 2019. Initial culture of groundnut bruchid, *C. serratus* (Olivier), was collected from naturally infested pods. The beetle was identified by the small black markings on the elytra, incompletely covering the abdomen, broad hind femur with serrated antennae. The bruchid was then multiplied under laboratory conditions at 25±2°C and 70% RH using the groundnut pods. The bruchid population was maintained in the plastic jars. Life stages of *C. serratus* on groundnut pods were studied under laboratory condition. After the adult emergence, a pair of male and female adults was kept in a container for mating and allowed for egg laying. Three vials were taken and 30 groundnut kernels with freshly laid egg of *C. serratus* such that one egg per kernel were studied by putting it into vial and the open end of the vial was tied with muslin cloth. Observations were taken on different parameters like grub period, pupal period, adult longevity and total life period.

Egg incubation period is the length of time taken from egg laying to hatching. It can be recognized by egg turning to opaque due to accumulation of bored material in the chorion. The grub period was recorded as the number of days taken from hatching of egg till last instar grub (i.e. fourth instar stage) spinned the papery cocoon. Pupal period is the period from the formation of cocoon till the adult emergence. Adult longevity is the period from adult emergence to its mortality. For management study, one kg pod was used for each treatment. 100 ppm stock solution of each insecticide was prepared. Required dose of insecticides was taken from 100 ppm stock solution for pod and storage bag treatment. In some treatment pods were treated with insecticides, shade dried, packed in 1 kg capacity cloth bag. In other treatments storage bags were treated with insecticides, shade dried and filled with pods. Both treated pods filled in storage bags and treated bags filled with pods were kept in laboratory under room temperature for further observations.

Treatment details

Sr. No.	Insecticide treatments	Quantity ml/l
T1.	Pod treatment with Flubendiamide 480 SC	2ml of 100 ppm concentration/l
T2.	Storage bag treatment with Flubendiamide 480 SC	2ml of 100 ppm concentration/l
T3	Pod treatments with Emamectin benzoate 5 SG	2ml of 100 ppm concentration/l
T4.	Storage bag treatment with Emamectin benzoate 5 SG	2ml of 100 ppm concentration/l
T5.	Pod treatment with Spinosad 45 SC	2ml of 100 ppm concentration/l
T6.	Storage bag treatment with Spinosad 45 SC	2ml of 100 ppm concentration/l
T7.	Pod treatment with Deltamethrin 2.8 EC	3.5ml of 100 ppm concentration/l
T8.	Storage bag treatment with Deltamethrin 2.8 EC	3.5ml of 100 ppm concentration/l
T9.	Control	

Per cent pod damage is calculated at monthly interval in such a way that in each treatment, the number of pods damaged among the total number of pods observed were counted and expressed as per cent pod damage. The per cent kernel damage taken at two month interval such that the number of kernel damaged among the total number of kernel observed was counted and expressed as per cent kernel damage. Numbers of live adults per treatment were counted in all the treatments at monthly interval.

Results and Discussion

The incubation period of egg ranged from 7 to 8 days. The freshly laid eggs of *C. serratus* were observed creamy, translucent with tough chorion. The egg shell becomes opaque white or grey at hatching. The grub of groundnut bruchid made a circular cut on the surface of egg chorion a day before hatching. The grub period was lasted for 32 to 34 days with an average of 33 days under room temperature. The grubs passed through four larval instars before pupation. The newly hatched first instar grub was creamy white in coloured C shaped with prominent mandibles. The full grown matured grub turned light pink colour before pupation. The pupal period was observed ranging between 12 to 15 days with an average of 13.5 days under room temperature. The pupa was dull white and papery. Adult period was found ranging from 14 to 16 days with a mean of 15 days in case of males, whereas it was 20 to 25 days with a mean of 22.50 days in case females of groundnut bruchid. Groundnut bruchid adult was reddish dark brown in colour with small markings on the elytra, prominent compound eyes and 11 segmented antennae and showed sexual dimorphism where, antennae were long and serrated in males than in females, whereas the pygidium (dorsum of posterior abdomen) was exposed in females than in males. In males pygidium was projected down wards, so that in dorsal view it was hidden by the elytra. In case of females the pygidium was visible dorsally projecting beyond the elytra. The females were slightly bigger than males. Total life period of the male *C. serratus* from egg to adult ranged from 65 to 73 days with an average mean of 69 days. In case of female, the total life period varied from 71 to 82 days with mean of 76.50 days.

Mishra and Ranjan (2005) and Sakhare et al. (2018) reported 4.20 days and 3.50 to 8.50 days as egg incubation period of *C. serratus*, respectively. The grub period of *C. serratus* was 34.69 days, 19 to 38 days, 29 to 41 days and 28 to 34 days of grub period, respectively reported by Joshi and Ghorpade (2001), Sandeep (2005), Bhogeesh et al. (2014) and Sakhare et al. (2018) who recorded. While, Mishra & Ranjan (2005) and Behera et al. (2016) reported 26.68 days and 42.2 days of grub period, respectively. Sakhare et al. (2018) recorded 12.75 to 15.25 days of pupal period. Bhogeesh et al. (2014) who recorded 14.80 days as male adults period and 21.34 days as female adults period. Sundria et al. (2004) and Sakhare et al.(2018), who recorded 40.54 to 78.35 days, 89.9±3.44 days and 67.50 to 76.00 days life period of groundnut bruchids *C. serratus*, respectively.

No pod damage was observed after one month of storage. Further after second and third month of storage all treatments showed no pod damage, while pod damage was seen in untreated control i.e. 6.67% during second month and 13.00% during third month, showing all treatments varied significantly over untreated control. Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l recorded the lowest pod damage even up to seven month of storage. The best treatment was pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l which was found at par with pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l. Pod treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l was next effective treatment followed by storage bag treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l, storage bag treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l, storage bag treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l, pod treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l, storage bag treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l. Maximum pod damage was found in untreated control(Table 1). These findings obtained support from Bhogeesh et al. (2014), evaluated different insecticides like Flubendiamide 480 SC, Emamectin benzoate 5 SG, Spinosad 45 SC and Deltamethrin 2.8 EC against *C. serratus*. However, all the insecticides were proved effective in controlling *C. serratus* without affecting the seed quality attributes; Deltamethrin 2.8 EC was found superior over all other insecticides. Spinosad 45 SC @ 100 ppm a.i., Emamectin benzoate 5 SG @ 100 ppm a.i. and Flubendiamide 480 SC @ 100 ppm a.i. were next in the order of efficacy. Sundria (2004) reported that Deltamethrin 10g/kg appeared to be the best protectant, showing no oviposition, and zero per cent adult emergence, weight loss and damage, even after nine months of storage. Nadaf et al. (2010) studied the effect of grain protectants against groundnut bruchid, *C. serratus* in the laboratory. Spinosad and Deltamethrin proved their merit throughout experimental period by achieving zero per cent pods with egg, pod damage for first two months and adult emergence for first three months after treatment. Huang and Subramanyam (2007) evaluated the efficacy of Spinosad on shelled corn in the laboratory against seven major stored grain insects species viz. red flour beetle, *Tribolium castaneum*; rusty grain beetle, *Cryptolestes ferrugineus*; lesser grain borer, *Rhyzopertha dominica*; sawtoothed grain beetle, *Oryzaephilus surinamensis*; rice weevil, *Sitophilus oryzae*; maize weevil, *Sitophilus zeamais*; and Indian meal moth, *Plodia interpunctella*. He found that Spinosad at 1 or 2 mg/kg provided complete or near complete suppression of progeny production and kernel damage of all species after 49 days. The results indicated that Spinosad at the rate of 1 mg/kg was effective against all the seven stored grain insect pests on corn. Emamectin Benzoate had an adverse effect on stored grain pest *Cryptolestes ferrugineus* and with an increase in concentration the effect also increases (Ramesh Babu et al. 2018). Patil et al. (2004) investigated the efficacy of gunny bag treatments with insecticides in controlling *Rhizopertha dominica*. Wheat seeds stored in gunny bags which were presoaked in Deltamethrin, Bifenthrin and Malathion were tested and they recorded minimum damage in gunny bag treatment soaked in Deltamethrin @ 40mg/kg of seeds. Ummer (2012) conducted an experiment on management of groundnut bruchid, *C. serratus* (Olivier) during storage. Deltamethrin @ 30 mg a.i/m^2 was found most effective insecticide against *C. serratus* when sprayed on surface of gunny bag over untreated control. Raheem and Sridevi (2011) was found that Abamectin was the most effective insecticide against *Callosobruchus chinenesis* L. followed by Deltamethrin, Spinosad, Emamectin Benzoate, Lufenuron, Novaluron and Neem.

Table 1: Influence of pod and storage bag treatment with different insecticides on pod damage

Tr. No.	Insecticide treatments	Pod damage (%)							
		1 MAT	2 MAT	3 MAT	4 MAT	5 MAT	6 MAT	7 MAT	8 MAT
T1	Pod treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)*	0 (0.71)*	10.67 (3.27)**	21.00 (27.27)***	29.00 (32.58)***	38.33 (38.25)***	45.67 (42.51)***
T2	Storage bag treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	12.67 (3.56)	23.00 (28.66)	34.00 (35.67)	43.00 (40.97)	52.00 (46.15)
T3	Pod treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	2.00 (1.38)	5.00 (12.88)	9.00 (17.44)	11.67 (19.97)	19.67 (26.32)

Tr. No.	Insecticide treatments	Pod damage (%)							
		1 MAT	2 MAT	3 MAT	4 MAT	5 MAT	6 MAT	7 MAT	8 MAT
T4	Storage bag treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	6.33 (2.52)	17.33 (24.60)	25.67 (30.44)	36.33 (37.07)	41.00 (39.82)
T5	Pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	3.00 (1.72)	4.00 (11.48)	5.00 (12.88)	9.00 (17.44)	13.67 (21.69)
T6	Storage bag treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	8.67 (2.94)	12.33 (20.56)	19.00 (25.84)	27.00 (31.30)	35.67 (36.66)
T7	Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	1.33 (1.14)	3.00 (9.88)	4.00 (11.48)	6.33 (14.51)	15.33 (23.05)
T8	Storage bag treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	3.33 (1.82)	6.67 (14.95)	10.00 (18.42)	14.33 (22.24)	22.00 (27.97)
T9	Control	0	6.67 (2.68)	13.00 (3.67)	25.33 (5.03)	40.33 (39.43)	51.00 (45.57)	60.33 (50.97)	76.67 (61.12)
	F' test	-	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±	-	0.02	0.03	0.11	0.57	0.53	0.58	0.71
	CD at 5%	-	0.06	0.08	0.33	1.66	1.54	1.69	2.07
	CV (%)	-	3.92	4.36	7.51	4.69	3.59	3.33	3.41

* Figures in the parenthesis indicate$\sqrt{X+0.5}$ square root transformed values; ** Figures in the parenthesis indicate square root transformed values;

Result presented in table 2 indicated that pods and storage bags treatments showed significant difference in respect of per cent kernel damage over untreated control. It is noticed from present findings that no kernel damage was found in all pod and storage bag treatments after second month of storage period, while 6.00% kernel damage was found in the untreated control. Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l recorded minimum per cent kernel damage after fourth and sixth month of storage period. Pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l recorded minimum kernel damage after eighth month of storage. Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l was found at par with pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l. The next effective treatment was pod treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l which was at par with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l. Huang and Subramanyam (2007) evaluated Spinosad against seven major stored grain insects on shelled corn in the laboratory. Insect species tested were the red flour beetle, rusty grain beetle, lesser grain borer, sawtoothed grain beetle, rice weevil, maize weevil, and Indian meal moth. Corn kernels were treated with Spinosad at 0, 0.1, 0.5, 1, and 2 a.i. (active ingredient) mg/kg for controlling the seven species. Spinosad at 1 or 2 mg/kg provided complete or near complete suppression of progeny production and kernel damage of all species after 49 days. Mishra and Ranjan (2005) recorded Deltamethrin @ 1.0 mg a.i./kg as the most effective one pod protectant. Choudhary et al. (2014) studied the seed protectants against *Callosobruchus chinensis* (L.) on Soybean *Glycine max* (L.) under storage condition and found that Deltamethrin 2.8 EC, Cypermethrin 10 EC, Spinosad 45 SC and Fenvalerate 20 EC @ 4 ppm emulsion/ suspension were more effective against *C. chinensis.*

Table 2: Influence of pod and storage bag treatment with different insecticides on kernel damage

Tr. No.	Insecticide treatments	Kernel damage (%)			
		2 MAT	4 MAT	6 MAT	8 MAT
T1	Pod treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l	0 (0.71)*	10.33 (18.75)**	30.00 (33.20)**	49.67 (44.81)**
T2	Storage bag treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l	0 (0.71)	12.00 (20.26)	37.00 (37.46)	57.33 (49.22)
T3	Pod treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l	0 (0.71)	2.00 (7.95)	13.00 (21.13)	21.33 (27.49)

Tr. No.	Insecticide treatments	Kernel damage (%)			
		2 MAT	4 MAT	6 MAT	8 MAT
T4	Storage bag treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l	0 (0.71)	5.67 (13.76)	28.67 (32.37)	45.00 (42.13)
T5	Pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l	0 (0.71)	3.33 (10.50)	6.00 (14.15)	16.33 (23.82)
T6	Storage bag treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l	0 (0.71)	8.33 (16.77)	18.00 (25.10)	35.00 (36.27)
T7	Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l	0 (0.71)	1.33 (6.54)	4.33 (11.90)	18.67 (25.57)
T8	Storage bag treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l	0 (0.71)	4.67 (12.46)	15.67 (23.31)	26.00 (30.65)
T9	Control	6.00 (2.55)	31.33 (34.04)	59.33 (50.38)	82.00 (64.95)
	F' test	Sig.	Sig.	Sig.	Sig.
	SE (m) ±	0.04	0.61	0.64	0.78
	CD at 5%	0.11	1.76	1.87	2.28
	CV (%)	7.21	6.71	4.02	3.54

* Figures in the parenthesis indicate $\sqrt{X+0.5}$ square root transformed values; ** Figures in the parenthesis indicate arc sign transformed values.

The average numbers of live adults/kg of pods of groundnut bruchid in 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th months of storage of pod treatment and storage bag treatment presented in table 3 revealed that all the treatments were significantly superior over untreated control. In the present investigation it was found that no live adults were found up to the third month of storage period from pod and storage bags treated with different insecticides. 4.33 and 10.00 adults/kg of pods were found in untreated control during second and third month of storage respectively. Significantly minimum numbers of live adults/kg of pods were found in pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l followed by pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l, pod treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l, storage bag treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l, storage bag treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l, storage bag treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l, pod treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l, storage bag treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l. These findings gained support from Bhogeesh et al. (2014) who evaluated different insecticides like Flubendiamide 480 SC, Emamectin benzoate 5 SG, Spinosad 45 SC and Deltamethrin 2.8 EC and found that least number of adults recorded in Deltamethrin 2.8 EC at 100 ppm. Spinosad 45 SC at 100 ppm a.i., Emamectin benzoate 5 SG at 100 ppm a.i. and Flubendiamide480 SC at 100 ppm a.i. were next in the order of efficacy. It is also reported that among the insecticides Deltamethrin 2.8 EC proved better in controlling the attack of *C. serratus* in stored groundnut. Nadaf et al. (2010) studied the effect of grain protectants against groundnut bruchid, *C. serratus* in the laboratory. The pods treated with Spinosad and Deltamethrin proved their merit throughout experimental period protected the pods effectively against *C. serratus* by recording minimum pod damage and achieving zero adult emergences for first three months after treatment. Huang and Subramanyam, 2007, found that Spinosad at the rate of 1 mg/kg was effective for reducing population of *C. maculatus* and suppressed the progeny production depended on its concentration and the period of exposure to it. Spinosad at the rate of 1 mg/kg was effective for reducing population of stored grain insect pest. Flinn et al. (2004) suggested that Spinosad is very effective in suppressing *Rhizopertha dominica*, *Cryptolestes ferrugineus* and *Tribolium castaneum* populations in stored wheat.

Raheem and Sridevi (2011) reported that Deltamethrin, Spinosad and Emamectin benzoate were toxic to the adults of *Callosobruchus chinensis* and found minimum numbers of adults in seeds treated with Deltamethrin followed by Spinosad and Emamectin benzoate, Lufenuron, Novaluron, Neem and untreated control. Choudhary et al. (2014) evaluated deltamethrin 2.8 EC, cypermethrin 10 EC, spinosad 45 SC and fenvalerate 20 EC against *Callosobruchus chinensis* and the insecticide deltamethrin 2.8 EC recorded significantly higher mortality and lower number of adult emergence. Emamectin benzoate @ 40.0 mg/kg of seed recorded minimum mean beetle population after six months of storage in gunny bags and it was superior to Spinosad @ 4.4 mg/kg and Deltamethrin 2.8 EC @ 40.0 mg/kg (Kumari et al. 2014).

Table 3: Influence of pod and storage bag treatment with different insecticides on emergence of live adults

Tr. No.	Insecticide treatments	Live adults/kg of pods							
		1 MAT	2 MAT	3 MAT	4 MAT	5 MAT	6 MAT	7 MAT	8 MAT
T1	Pod treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)*	0 (0.71)*	4.67 (2.16)**	10.00 (3.16)**	23.00 (4.80)**	35.00 (5.92)**	44.33 (6.66)**
T2	Storage bag treatment with Flubendiamide 480 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	11.00 (3.31)	22.00 (4.69)	31.67 (5.63)	40.33 (6.35)	50.67 (7.12)
T3	Pod treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	1.67 (1.28)	4.00 (1.99)	7.33 (2.79)	10.00 (3.16)	17.67 (4.20)
T4	Storage bag treatment with Emamectin Benzoate 5 SG @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	5.67 (2.38)	11.33 (3.37)	26.67 (5.16)	33.00 (5.74)	40.33 (6.35)
T5	Pod treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	2.67 (1.63)	3.00 (1.72)	4.33 (2.06)	7.67 (2.76)	12.00 (3.45)
T6	Storage bag treatment with Spinosad 45 SC @ 2ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	6.00 (2.44)	12.67 (3.56)	24.00 (4.90)	21.00 (4.58)	34.00 (5.83)
T7	Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	1.00 (1.00)	2.00 (1.38)	3.67 (1.91)	5.00 (2.23)	10.33 (3.21)
T8	Storage bag treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l	0	0 (0.71)	0 (0.71)	3.00 (1.73)	5.33 (2.31)	9.00 (2.99)	13.33 (3.65)	21.00 (4.58)
T9	Control	0	4.33 (2.20)	10.00 (3.24)	23.33 (4.83)	38.67 (6.22)	47.00 (6.86)	58.67 (7.66)	76.00 (8.72)
	F' test	-	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	SE (m) ±	-	0.03	0.03	0.08	0.11	0.11	0.09	0.13
	CD at 5%	-	0.07	0.09	0.23	0.33	0.32	0.28	0.37
	CV (%)	-	4.94	5.21	5.96	6.27	4.58	3.56	3.94

* Figures in the parenthesis indicate $\sqrt{X+0.5}$ square root transformed values; ** Figures in the parenthesis indicate square root transformed values.

Conclusions

Pod treatment with Deltamethrin 2.8 EC @ 3.5ml of 100 ppm concentration/l kept the groundnut pod damage due to *Caryedon serratus* below 10 per cent i.e 6.33 per cent up to seventh month of the storage.

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Effect of Potting Mixture and Pot Size on Flower Quality and Economics of Potted Calendula Plants

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Abstract: Potted ornamental and annual flowering plant trading is gaining importance in domestic as well as in international market. By adoption of some improved techniques, the quality and cost benefit ratio of potted plants can be increased. Hence the present study was carried out at Horticulture Section, College of Agriculture, Nagpur during *rabi* season of 2019-2020 to find out the most suitable potting mixture and pot size for producing the best flower quality and economics of calendula. The experiment was laid out in Factorial Completely Randomized Design with 27 treatment combinations of nine potting mixture and three pot sizes and was replicated thrice with twenty pots treatment^{-1}. Nine potting mixtures viz., Garden Soil, Garden Soil + Sand (2:1), Garden Soil + FYM (2:1), Garden Soil + Vermicompost (2:1), Garden Soil + Cocopeat (2:1), Garden Soil + Sand + FYM (2:1:1), Garden Soil + Sand + Vermicompost (2:1:1), Garden Soil + Sand + Cocopeat (2:1:1) and Garden Soil + FYM + Vermicompost + Cocopeat (2:1:1:1) and pot size of 12.5 cm height × 12.5 cm diameter,15 cm height × 15 cm diameter and17.5 cm height × 17.5 cm diameter were tested. Observations were noted for flower quality and economics of potted calendula.

The potting mixture Garden Soil + FYM + Vermicompost + Cocopeat (2:1:1:1) recorded significantly maximum diameter of flower (6.41 cm), weight of flower (4.50 g) and weight of flower pot^{-1} (177.31 g). With respect to the effect of pot sizes, 17.5 cm height × 17.5 cm diameter pots exhibited maximum diameter of flower (5.73 cm), weight of flower (4.05 g) and weight of flower pot^{-1} (135.91 g). Gross income, net returns and B:C ratio also recorded the same trend. The highest net return of Rs. 73300.67/treatment was obtained in treatment combination of potting mixture, Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) and pot size of 17.5 cm height × 17.5 cm diameter with benefit cost ratio of 1.56.

Keywords: Potted calendula, potting mixture, pot size, flower quality, economics.

Introduction

Calendula plants are very popular for growing in beds as well as pot plants, as a cut flower and also grown in window boxes. Today potted plants have become very popular and are highly cherished among people due to their fascinating appearance, attractive colours, long lasting nature, vivid, vibrant and vivacious flowers and foliage as well as their overall present ability.

The presence of sufficient nutrition, good water holding capacity, porosity and plug formation ability of media increases the root and shoot growth, which ultimately, leads to early and high yield of the crop (Chong, 2008). Container size also plays an important role in manipulating the growth, development and flowering besides the presentation of potted plants. The container size alters the rooting volume of the plants. This in turn greatly affects plant growth and flowering as well. In general, as container size increases, leaf area, shoot bio-mass and root bio-mass increase linearly (Cantliffe, 1993).

Pot plant trading is recently gaining the impetus of an industry with the growing demands of quality ornamental plants in domestic as well as international trade. Foliage as well as flowering annual and perennials are popular for potted plants. However, increasing the demand of potted plant there is a good scope for increasing the production of better quality potted flower plant by adopting some improved techniques like application of potting mixture and pot size which manipulates the growth and flowering of many ornamental plants and thus, found beneficial. For increasing in the growth and quality, the role of potting mixture and pot size is very important. Hence, the present experiment was carried out.

Objectives

1) To study the effect of different potting mixture and pot size on flower quality and economics of calendula.

Material and Methods

A field experiment was carried out at Floriculture Unit, Horticulture Section, College of Agriculture, Nagpur during *rabi* season of 2019-20 to study the effect of potting mixture and pot size on growth and flowering of calendula. Present study consisted of nine potting mixture viz.,M_1 - Garden Soil, M_2 - Garden Soil + Sand (2:1), M_3 - Garden Soil + FYM (2:1), M_4 - Garden Soil + Vermicompost (2:1), M_5 - Garden Soil + Cocopeat (2:1), M_6 - Garden Soil + Sand + FYM (2:1:1), M_7 - Garden

Soil + Sand + Vermicompost (2:1:1), M_8 - Garden Soil + Sand + Cocopeat (2:1:1), M_9 - Garden Soil + FYM + Vermicompost + Cocopeat (2:1:1:1) and three pot sizes i.e.S_1 - 12.5 cm height × 12.5 cm diameter, S_2 – 15 cm height × 15 cm diameter, S_3 - 17.5 cm height × 17.5 cm diameter in Factorial Completely Randomized Design with 27 treatment combinations, replicated thrice. Nine potting mixtures were prepared after thoroughly mixing of various ingredients on volume by volume basis and pots filled with different potting mixture. Seeds of calendula were sown in pots of different sizes and were regularly watered once a day. Observations were recorded for various growth, flowering and economic parameters of calendula.

Results and Discussion

Effect of potting mixture and pot size on flower quality parameters:

Diameter of flower

It is well evident from table 1, that there exhibited significant differences among the different potting mixtures used for growing of calendula. Maximum diameter of flower (6.41 cm) was found in potting mixture Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1). Significantly minimum diameter of flower (3.67 cm) was recorded in potting mixture Garden soil + Sand + Cocopeat (2:1:1). Increase diameter of flower is mainly due to genetic makeup and which might have been further modified by prevailing environmental condition and potting media combination of Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1). It helps in more accumulation of photosynthesis in the sink (flower) from source (leaves). Continuous availability of photosynthates, cell division, cell elongation and cell enlargement remain on peak resulted in higher flower diameter. Similar results were also observed by Thakur *et al.* (2013) and Kala *et al.* (2020).

As regard the effect of pot sizes maximum diameter of flower (5.73 cm) was recorded in pot size 17.5 cm height × 17.5 cm diameter. Whereas minimum diameter of flower (5.08 cm) was recorded in 12.5 cm height × 12.5 cm diameter pot size. The present findings might be due to the reason that the capacity of pots to accommodate more potting mixture and assuring more space for root growth and development besides providing the nutrients to the growing plant. It is a well proven fact that there is a linear relationship between pot size and growth of plant. As the size of the pots increases, there is corresponding increase in the growth and flowering attributes of plants and vice-versa. Similar types of results are also reported by Vernieri *et al.* (2003) and Gupta (2013).

The interaction effect of potting media and pot size however exhibited non-significant effect.

Table 1. Effect of potting mixture and pot size on flower quality parameters of calendula

Treatments	Diameter of flower (cm)	Weight of flower (g)	Weight of flowers pot^{-1} (g)
Potting mixture (M)			
M_1	5.20	3.68	64.14
M_2	5.59	3.91	70.19
M_3	5.84	4.15	117.31
M_4	6.14	4.39	148.96
M_5	3.82	2.76	26.45
M_6	5.63	4.00	113.42
M_7	5.92	4.25	119.67
M_8	3.67	2.56	24.12
M_9	6.41	4.50	177.31
F Test	Sig.	Sig	Sig.
S.E. (m) ±	0.08	0.04	2.74
C D at 5%	0.23	0.14	7.78
Pot size (S)			
S_1	17.62	3.59	60.05
S_2	19.72	3.76	91.23
S_3	23.03	4.05	135.91
F test	Sig.	Sig.	Sig.
S.E. (m) ±	0.04	0.02	1.58
CD at 5%	0.13	0.08	4.49
Interaction M X S			
F test	N.S.	N.S.	Sig.
S.E. (m) ±	0.17	0.10	5.81
CD at 5%	-	-	16.50

Weight of flower

Significantly maximum weight of flower (4.50 g) was found in potting mixture Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1). Significantly minimum weight of flower (2.56 g) was recorded in potting mixture Garden soil + Sand + Cocopeat (2:1:1). The present findings might be due to the reason that, same treatment recorded better flower parameters such as diameter of flower, thickness of flower stalk and stalk length of flower than other treatments. This is in confirmation with the findings of Chauhan *et al.* (2014) in gerbera

As regards to the pot size, significantly maximum weight of flower (4.05 g) was recorded in big pot size of 17.5 cm height × 17.5 cm diameter. Whereas, minimum weight of flower (3.59 g) was recorded in small pots of 12.5 cm height × 12.5 cm diameter.

The interaction effect of potting media and pot size on weight of flower however exhibited non-significant effects.

Weight of flowers pot^{-1}

There exhibited significant differences amongst different potting mixtures used for growing of calendula. Maximum weight of flowers pot^{-1} (177.31 g) was obtained in potting mixture Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) which was followed by M_4 -Garden soil + Vermicompost (148.96 g). Significantly minimum weight of flowers pot^{-1}(24.12 g) was recorded in potting mixture M_8 - Garden soil + Sand + Cocopeat. Potting mixture Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) proved maximum flower pot^{-1} due to more availability of nutrients, media and genetic makeup. Similar finding have been reported by Bergi *et al.* (2015) in gerbera.

Significantly maximum weight of flowers pot^{-1} (135.91 g) was recorded in big pot size of 17.5 cm height × 17.5 cm diameter. Whereas, minimum weight of flowers pot^{-1} (60.05 g) was recorded in 12.5 cm height × 12.5 cm diameter pot size. This might be due to the same treatment recorded maximum branches plant^{-1}, better flower parameters such as diameter of flower, more number of flowers plant^{-1} and maximum weight of single flower.

The interaction effect of potting mixtures and pot size on weight of flowers pot^{-1} also exhibited significant effect.

Table 2. Effect of potting mixture and pot size on economic parameters of calendula

Treatment combination	Total cost (Rs)	Price/pot (Rs)	Gross income (Rs)	Net return (Rs)	B:C ratio
M_1S_1	25257.33	50	50000	24742.67	0.97
M_1S_2	34007.33	70	70000	35992.67	1.05
M_1S_3	46507.33	95	95000	48492.67	1.04
M_2S_1	25507.33	50	50000	24492.67	0.96
M_2S_2	34507.33	70	70000	35492.67	1.02
M_2S_3	47507.33	95	95000	47492.67	0.99
M_3S_1	25057.33	55	55000	29942.64	1.19
M_3S_2	33607.33	75	75000	41392.67	1.23
M_3S_3	45707.32	105	105000	59292.67	1.29
M_4S_1	25507.33	60	60000	34492.67	1.35
M_4S_2	34507.33	85	85000	50492.67	1.46
M_4S_3	47507.33	120	120000	72492.67	1.52
M_5S_1	25303.33	40	40000	14696.67	0.58
M_5S_2	34099.33	55	55000	20900.67	0.61
M_5S_3	41691.33	75	75000	33308.67	0.79
M_6S_1	25294.33	55	55000	29705.67	1.17
M_6S_2	34082.33	75	75000	40917.67	1.20
M_6S_3	46657.33	110	110000	63342.67	1.35
M_7S_1	25932.33	60	60000	34067.67	1.31
M_7S_2	34297.33	80	80000	45702.67	1.33
M_7S_3	48007.33	115	115000	66992.67	1.39
M_8S_1	25479.33	40	40000	14520.67	0.56
M_8S_2	34451.33	55	55000	20548.67	0.59
M_8S_3	47395.33	75	75000	27604.67	0.58

Treatment combination	Total cost (Rs)	Price/pot (Rs)	Gross income (Rs)	Net return (Rs)	B:C ratio
M_9S_1	25305.33	60	60000	34694.67	1.37
M_9S_2	34103.33	85	85000	50896.67	1.49
M_9S_3	46699.33	120	120000	73300.67	1.56

Effect of potting mixture and pot size on economic parameters

Economics for each treatment combination was worked out for raising of 1000 pots of calendula. Selling price also differed as per the growth of plants, flower quality and pot size. Accordingly BC ratio was calculated (Table 2).

Benefit Cost Ratio

The highest net return Rs. 73300.67/treatment was obtained in treatment combination M_9S_3 [Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) and 17.5 cm height × 17.5 cm diameter] with benefit cost ratio of 1.56. Whereas, minimum net return Rs.14520.67/treatment was obtained in treatment combination M_8S_1 [Garden soil + Sand + Cocopeat (2:1:1) and S_1 - 12.5 cm height × 12.5 cm diameter] with benefit cost ratio of 0.56.

Summary and Conclusion

The potting mixtures and pot size showed significant differences for flower quality and economic parameters of calendula. Garden Soil + FYM + Vermicompost + Cocopeat (2:1:1:1) recorded significantly maximum diameter of flower (6.41 cm), weight of flower (4.50 g) and weight of flower pot^{-1} (177.31 g).

With respect to the effect of pot sizes, 17.5 cm height × 17.5 cm diameter pots exhibited maximum diameter of flower (5.73 cm), weight of flower (4.05 g) and weight of flower pot^{-1} (135.91 g).

The highest net return of Rs. 73300.67/treatment was obtained in treatment combination of potting mixture, Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) and pot size of 17.5 cm height × 17.5 cm diameter with benefit cost ratio of 1.56.

From the present study, it may be concluded that different potting mixtures and pot size has significantly affected flower quality and economic parameters of calendula. Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) with big pot size 17.5 cm height × 17.5 cm diameter attained maximum diameter of flower, weight of flower, weight of flower pot^{-1}and highest gross and net monetary return with highest B:C ratio. Since the results are based on one season trial, more experimentation for confirmation of findings is required.

Implications

For obtaining better flower quality and higher monetary returns from potted calendula, raising of calendula plants in potting mixture of Garden soil + FYM + Vermicompost + Cocopeat (2:1:1:1) and big size pots of 17.5 cm height × 17.5 cm diameter for can be recommended.

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Evaluation of Genetic Diversity in Soybean (*Glycine max* (l.) Merill) Germplasm

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Abstract: Inorder to assess genetic diversity in soybean germplasm, a total of 100 genotypes along with 5 checks were evaluated in Augmented Block Design with 4 blocks at Regional Research Centre (Dr. PDKV), Amravati during *kharif* 2019. The observations were recorded for nine agro-morphological characters. The genotypes and checks were grouped into 6 clusters, the maximum inter cluster distance was found between the cluster VI and IV (33.35) followed by cluster IV and II (29.72), cluster IV and V (29.24), it can be inferred that crossing between genotypes present in these clusters might be contribute in good recombinant for successful breeding programme. The important traits contributed maximum towards genetic diversity were plant height (37.05%), number of pods per plant (34.16%) and days to 50% flowering (12.09%). On the basis of mean and inter-cluster distance the following genotypes were selected to be utilized as donor, like NRC 105, JS 20-34 and JS 95-60 for earliness; Kalitur and AGS 25 for more number of pods and branches; Karune for bold seedness and AMS 100-39, AMS 2014-1 and AMS 48-7-3 for high seed yield.

Keywords: Soybean, Genetic diversity, D^2 statistic, cluster analysis

Introduction

Soybean (*Glycine max* (L.) Merill.) popularly known as "Golden Bean" or "Miracle crop" is a member of leguminaceae family. It was cultivated in China from 3000 BC. Cultivated soybean is a diploid crop having chromosome number 2n=40. It is basically a self-pollinated, leguminous crop but widely used as oilseed crop. Soybean is a one of the richest sources of oil as well as high quality protein. In addition, it contains a good amount of minerals, salts and vitamins (Thiamine and Riboflavin). It has a vast multiplicity of use as food and industrial products and is some time called a wonder crop (Gopinath and Pavadi, 2015).

The success or failure of any crop breeding programme depends largely on the amount of genetic variability present in the breeding materials. It is essential to properly characterize and evaluate the available germplasm. Diversity in germplasm is an important prerequisite for hybridization program. Evaluation of genetic diversity would promote the efficient use of genetic variations in the breeding program. Numerous studies have explored the significance of phenotypic characterization in estimating diversity in soybean.

Material and Methods

The experiment material consists of 100 soybean germplasm lines with 5 checks and was evaluated in Augmented Block Design with 4 blocks at the field of Regional Research Centre (Dr. PDKV), Amravati during *kharif* 2019 with spacing 45 x 5 cm. The genotypes were selected from core germplasm available at Regional Research Centre (Dr. PDKV), Amravati. All recommended package of practices was followed during the crop growth period. Observations were recorded for nine agro-morphological characters *viz.* on plot basis days to 50% flowering (days), days to maturity (days) and on plant basis plant height (cm), number of branches per plant, number of pod clusters per plant, number of pods per plant, number of seeds per pod, 100 seed weight (g) and seed yield per plant (g). The mean of different characters were calculated on the basis of these individual data recorded for each character in each replication and subjected for statistical analysis suggested by Rao (1952). Rao (1952) described the multivariate analysis of genetic divergence using Mahalanobis's D^2 statistic (1936).

Results and Discussion

In any crop improvement programme, genetic diversity plays an important role. In fact, it is an essential pre-requisite while initiating hybridization programme because the choice of potential and diverse parents determines the success of such programme and will serve the purpose of combining desirable genes so as to obtain superior recombinations. Assessment of genetic divergence by the use of D^2 statistics is useful in choosing parents for many breeding objectives (Murthy, 1965).

The genotypes and checks were grouped into 6 clusters (Fig. 1). The average inter cluster distance was maximum between clusters IV and VI (33.35), followed by clusters II and IV (29.72), clusters IV and V (29.24), clusters I and IV (27.46), clusters III and VI (23.97) cluster III and VI (21.19) and cluster II and III (20.82). As cluster V has only one genotype, the intra-cluster value is zero. While the maximum intra cluster distances as observed for cluster VI (13.64) followed by cluster III (12.37). Lower intra cluster distances, indicates the presence of narrow genetic variation within a cluster (Table 1). The present study revealed the presence of considerable amount of genetic diversity among the genotypes studied. Further 105 genotypes were grouped into 6 clusters by Tocher's method (Rao, 1952). Cluster I was the largest having 60 genotypes followed by cluster III with 22 genotypes, cluster II (12 genotypes) whereas the smallest cluster V was containing only one genotype (Table 2).

Table 1: Average intra and inter cluster distance

Clusters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Cluster I	10.55	15.86	15.99	27.46	13.01	15.23
Cluster II		11.71	20.82	29.72	16.22	23.97
Cluster III			12.37	18.54	18.71	21.19
Cluster IV				11.15	29.24	33.35
Cluster V					0.00	19.01
Cluster VI						13.64

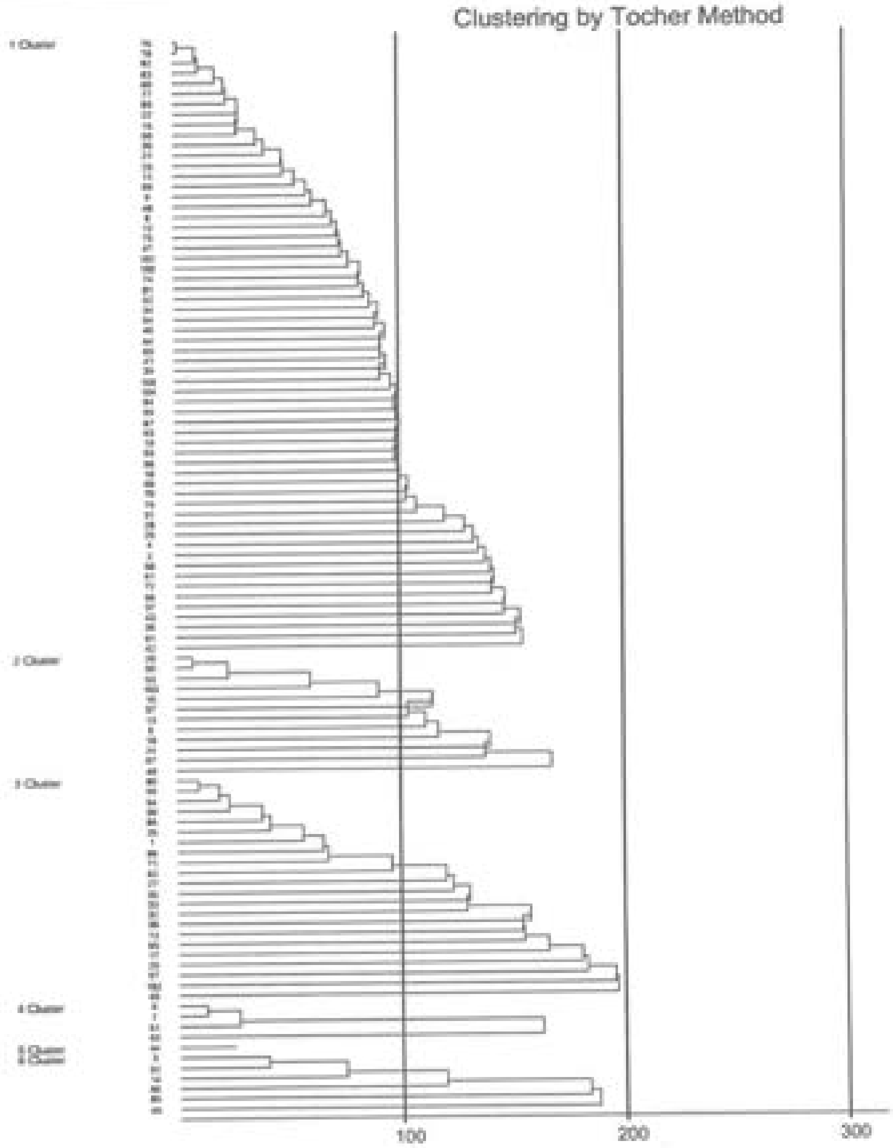

Figure 1.: Dendrogram

The Table 3 to revealed that the plant height showed highest per cent contribution towards genetic divergence (37.05%) followed by number of pods per plant (34.16%), days to 50% flowering (12.09%), days to maturity (4.84%), 100 seed weight (3.96%), number of pod clusters per plant (2.23%), seed yield per plant (2.01%), number of branches per plant (1.87%) and number of seeds per pod (1.79%). The highest magnitude of genetic diversity for plant height in soybean had also reported by Ramana and Satyanarayana (2006); for pods per plant by Das *et al.* (2001), Kayande *et al.* (2008) and Mahesh (2017). The high genetic diversity for plant height had also reported by Bartul *et al.* (1985) and Chikhale *et al.* (1992); for pods per plant by Dobhal (1995).

Table 2: Grouping of genotypes into different cluster

Cluster	No. of genotype	Genotypes
Cluster I	60	AMS 475, AMS 140, AMS 114,AMS 100, NRC 522, AMS 46-1-16, AMS 77-3-6, VLS 62, SL 790, JS 93-05, MACS-NRC 15-75, VLS 68, PS 1444, RSC 10-52, AMS 2018-1, NS 209, JS 20-29, DT 21, RVS 2001-18, AMS 243-7-1, JS 20-69, JS 335, AMS 22, AMS 5-39, AMS 2005-13, JS 21-71, MACS 1508, JS 20-53, MAUS 144, NRC 86-2, AMS 353, MAUS 49-1, DS 228, AMS 1001, NRC 86, AMS 21, NRC 138, AMS 158, NRC 21-72, Himso 1579, PK 416, AMS 2017-1, RSC 10-46, TAMS 38, AMS 99-33, AMS 60-2-34, MACS 1281, TS 86, TS 104, IC 118041, EC 519845, NRC 66, NRC 127, AMS 2014-1, AMS 0542-G, KDS 753, MAUS 71, KDS 7, AMS 160-2-12, MAUS 158.
Cluster II	12	Harasoya, NRC 146, JS 95-60, JS 20-34, Karune, NRC 148, RVSM 2011-35, UPSM 534, Himso 1685, PS 1450, NRC 2005-0-5-3, MAUS 162.
Cluster III	22	AMS 140(B), GBIC 18-75-8, AMS 596, AMS 25, AMS 31-1, TS 25, Bragg, AMS 115, AMS 100-39, NRC 142, TS 83, KDS 344, MACS 1188, MACS 1520, KDS 726, AMS-MB 5-18, NRC 37, Himso 1676, PK 1029, AMS 20-20, JS 97-52, MAUS 612.
Cluster IV	4	AGS 25, Kalitur, JS 96-31, AMS 595.
Cluster V	1	MAUS 1
Cluster VI	6	EC 519579, AMS 47, SL 744, NRC 105, AMS 48-7-3, JS 20-98.
Cluster I	60	AMS 475, AMS 140, AMS 114,AMS 100, NRC 522, AMS 46-1-16, AMS 77-3-6, VLS 62, SL 790, JS 93-05, MACS-NRC 15-75, VLS 68, PS 1444, RSC 10-52, AMS 2018-1, NS 209, JS 20-29, DT 21, RVS 2001-18, AMS 243-7-1, JS 20-69, JS 335, AMS 22, AMS 5-39, AMS 2005-13, JS 21-71, MACS 1508, JS 20-53, MAUS 144, NRC 86-2, AMS 353, MAUS 49-1, DS 228, AMS 1001, NRC 86, AMS 21, NRC 138, AMS 158, NRC 21-72, Himso 1579, PK 416, AMS 2017-1, RSC 10-46, TAMS 38, AMS 99-33, AMS 60-2-34, MACS 1281, TS 86, TS 104, IC 118041, EC 519845, NRC 66, NRC 127, AMS 2014-1, AMS 0542-G, KDS 753, MAUS 71, KDS 7, AMS 160-2-12, MAUS 158.
Cluster II	12	Harasoya, NRC 146, JS 95-60, JS 20-34, Karune, NRC 148, RVSM 2011-35, UPSM 534, Himso 1685, PS 1450, NRC 2005-0-5-3, MAUS 162.
Cluster III	22	AMS 140(B), GBIC 18-75-8, AMS 596, AMS 25, AMS 31-1, TS 25, Bragg, AMS 115, AMS 100-39, NRC 142, TS 83, KDS 344, MACS 1188, MACS 1520, KDS 726, AMS-MB 5-18, NRC 37, Himso 1676, PK 1029, AMS 20-20, JS 97-52, MAUS 612.
Cluster IV	4	AGS 25, Kalitur, JS 96-31, AMS 595.
Cluster V	1	MAUS 1
Cluster VI	6	EC 519579, AMS 47, SL 744, NRC 105, AMS 48-7-3, JS 20-98.
Cluster I	60	AMS 475, AMS 140, AMS 114,AMS 100, NRC 522, AMS 46-1-16, AMS 77-3-6, VLS 62, SL 790, JS 93-05, MACS-NRC 15-75, VLS 68, PS 1444, RSC 10-52, AMS 2018-1, NS 209, JS 20-29, DT 21, RVS 2001-18, AMS 243-7-1, JS 20-69, JS 335, AMS 22, AMS 5-39, AMS 2005-13, JS 21-71, MACS 1508, JS 20-53, MAUS 144, NRC 86-2, AMS 353, MAUS 49-1, DS 228, AMS 1001, NRC 86, AMS 21, NRC 138, AMS 158, NRC 21-72, Himso 1579, PK 416, AMS 2017-1, RSC 10-46, TAMS 38, AMS 99-33, AMS 60-2-34, MACS 1281, TS 86, TS 104, IC 118041, EC 519845, NRC 66, NRC 127, AMS 2014-1, AMS 0542-G, KDS 753, MAUS 71, KDS 7, AMS 160-2-12, MAUS 158.
Cluster II	12	Harasoya, NRC 146, JS 95-60, JS 20-34, Karune, NRC 148, RVSM 2011-35, UPSM 534, Himso 1685, PS 1450, NRC 2005-0-5-3, MAUS 162.

Cluster	No. of genotype	Genotypes
Cluster III	22	AMS 140(B), GBIC 18-75-8, AMS 596, AMS 25, AMS 31-1, TS 25, Bragg, AMS 115, AMS 100-39, NRC 142, TS 83, KDS 344, MACS 1188, MACS 1520, KDS 726, AMS-MB 5-18, NRC 37, Himso 1676, PK 1029, AMS 20-20, JS 97-52, MAUS 612.
Cluster IV	4	AGS 25, Kalitur, JS 96-31, AMS 595.
Cluster V	1	MAUS 1
Cluster VI	6	EC 519579, AMS 47, SL 744, NRC 105, AMS 48-7-3, JS 20-98.

Table 3: Contribution of each character towards genetic divergence

Source	Times rank first	% contribution
Days to 50% flowering	660	12.09
Days to maturity	264	4.84
Plant height (cm)	2023	37.05
No. of branches/plant	102	1.87
No. of pod cluster/plant	122	2.23
No. of pod /plant	1865	34.16
No. of seed /plant	98	1.79
100 seed weight (g)	216	3.96
Seed yield/plant (g)	110	2.01

Table 4: Cluster means for nine characters

	Days to 50% flowering	Days to maturity	Plant height	Number of branches/ plant	Number of pod cluster / plant	Number of pods /plant	Number of seeds / pod	100 seed weight (g)	Seed yield / plant (g)
Cluster I	42.57	96.81	38.52	2.47	4.97	30.14	1.95	10.73	5.51
Cluster II	40.07	95.75	43.34	2.00	4.01	20.40	1.92	13.34	4.75
Cluster III	45.87	99.93	47.58	2.44	5.67	35.07	1.86	10.38	5.99
Cluster IV	50.85	100.80	60.93	3.40	7.66	36.82	1.78	7.15	4.56
Cluster V	50.05	100.50	35.95	1.82	4.43	24.21	1.88	10.52	3.96
Cluster VI	41.72	95.43	31.57	2.53	5.36	37.00	1.90	9.62	5.92

The result of canonical analysis revealed that about 96.78% of the total variations were accounted by four canonical roots indicating that major portion of differentiation for nine characters among 105 genotypes has been completed in these four phases. In the present study, characters plant height, number of pods per plant, days to 50% flowering and days to maturity were important sources of variation.

In the present study, cluster means were calculated for all the character (Table 4) and the results indicated the importance of characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of pod cluster, number of pods per plant, number of seeds per pod, 100 seed weight and seed yield per plant. The canonical analysis also confirmed the importance of these characters towards genetic divergence.

On the basis of clusters formed the following genotypes were selected to be utilized as donor like NRC 105, JS 20-34 and JS 95-60 for earliness; Kalitur and AGS 25 for more number of pods and branches; Karune for bold seeded and AMS 100-39; AMS 2014-1 and AMS 48-7-3 for high seed yield (Table 5).

The perusal of mean in Table 2 revealed that inter-cluster distance were greater than intra-cluster distance revealing consider amount of genetic diversity among the genotype studied. In the present study; the cross AMS 48-7-3 x Kalitur, AMS 2014-1 x AGS 25 and AMS 100-39 x AMS 48-7-3 were suggested for getting more number of pods and branches with high yield. Similarly the cross combination JS 20-34 x Kalitur/AGS 25, AMS 48-7-3 x JS 95-60, AMS 100-39 x NRC 105 and AMS 100-39 x JS 95-60 were suggested for high yield with earliness. The cross combination Karune x Kalitur, AMS 48-7-3 x Karune and AMS 100-39 x Karune were suggested for getting extra bold seeded high yielding variety (Table 6).

Table 5: Genotype selected for different characters on the basis of cluster formed.

Sr. no.	Characters	Clusters	Genotypes selected from clusters formed
1	Early maturity (days)	I	IC 118041 (91), EC 519845 (92), NS 209 (93)
		II	JS 95-60 (92), JS 20-34 (92.8)
		VI	NRC 105 (92), EC 519579 (94)
2	Maximum plant height (cm)	IV	Kalitur (62.6), AMS 595 (61.8) AGS 25 (60.6), JS 96-31 (58.6)
		III	NRC 142 (55.4), AMS 100-39 (55.2)
3	Maximum number of branches	IV	Kalitur (4.4), AGS 25 (4.2)
		III	KDS 344 (4.2)
		I	NRC 127 (3.8), NRC 86-2 (3.8)
4	Maximum number of pod clusters per plant	VI	SL 744 (9.0)
		III	Himso 1676 (8.8)
		IV	Kalitur (8.6), AGS 25 (8.4)
		I	Himso 1579 (8.6)
5	Maximum number of pods per plant	VI	EC 519579 (43.8), AMS 47 (40.2)
		IV	AGS 25 (41.0), Kalitur (40.0)
		III	AMS-MB 5-18 (42.6), MACS 1188 (40.1), KDS 344 (39)
6	Maximum number of seeds per pod	I	AMS 2018-1 (2.85), JS 93-05 (2.68), AMS 475 (2.66), AMS 46-1-16 (2.51), AMS 140 (2.51)
		VI	AMS 48-7-3 (2.45)
7	Maximum 100 seed weight (g)	II	Karune (20.5), Himso 1685 (15.0), Harasoya (15.0), NRC 146 (15.0)
		III	KDS 726 (15.0)
		I	MACS-NRC 1575(14.5), NRC 21-71 (14.5)
8	Maximum seed yield per plant (g)	III	AMS 100-39 (8.20), MACS 1888 (7.90), AMS-MB 5-18 (7.84), KDS 726 (7.70), MACS 1520 (7.61)
		I	AMS 2014-1 (7.96)
		VI	AMS 48-7-3 (7.63)

Table 6: Maximum inter-cluster distance and cross combinations suggested

Sr. no.	Cluster combination	Average inter cluster distance	Cross combination suggested	Characters to be improved
1	IV x VI	33.35	AMS 48-7-3 x Kalitur/AGS 25	More no. of pods and branches with high yield
2	II x IV	29.72	JS 20-34 x Kalitur/AGS 25	Earliness with more no. of pods, branches and 100 seed weight
			Karune x Kalitur	Extra bold seeded with more no. of pods and branches
3	I x IV	27.46	AMS 2014-1 x AGS 25	More no. of pods, branches with high yield
4	II x VI	23.97	AMS 48-7-3 x Karune	Extra bold seeded with high seed yield
			AMS 48-7-3 x JS 95-60	High yield with earliness
5	III x VI	21.19	AMS 100-39 x NRC 105	High yield with earliness
			AMS 100-39 x AMS 48-7-3	High yield with more no. of pods.
6	II x III	20.82	AMS 100-39 x JS 95-60	High yield with earliness
			AMS 100-39 x Karune	Extra bold seeded with high seed yield

Conclusion

The present study indicated that the distribution of genotypes into different clusters was at random and sufficient D^2 values among different cluster suggests that the genetic constitution of the promising lines in one cluster is in close proximity with the promising lines in other clusters of the pair may lead to desirable segregants having broad genetic base through hybridization between genotypes of two distant clusters. This finding will be helpful in planning future hybridization programme should involving diverse genotypes for crop improvement.

In the present study; the following crosses were suggested for different characters, AMS 48-7-3 x Kalitur, AMS 2014-1 x AGS 25 and AMS 100-39 x AMS 48-7-3 were suggested for getting more number of pods and branches with high yield. Similarly the cross combination JS 20-34 x Kalitur/AGS 25, AMS 48-7-3 x JS 95-60, AMS 100-39 x NRC 105 and AMS 100-39 x JS 95-60 were suggested for high yield with earliness. The cross combination Karune x Kalitur, AMS 48-7-3 x Karune and AMS 100-39 x Karune were suggested for getting extra bold seeded high yielding variety.

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Knowledge of Paddy Growers About Integrated Nutrient Management Practices

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Abstract: Study entitled "Adoption of Integrated Nutrient Management Practices by paddy Growers" was undertaken in Gadchiroli district in Vidarbha region of Maharashtra state. Ex-post facto research design was used for the same. The farmers growing Paddy since last three years consecutively were identified and from each selected village 12 paddy growers as respondents were selected randomly to constitute sample size of 120 respondents. The data from paddy growers were collected by personal interview method.

Findings with regards to knowledge of paddy growers about integrated nutrient management practices revealed that majority of the paddy growers (84.17%) had knowledge about recommended dose of nitrogenous fertilizers; followed by 79.17 per cent paddy growers who possessed the knowledge about recommended dose of phosphatic fertilizers. A little more than three fourth (78.33%) of the paddy growers had knowledge about soil testing.

With regards to knowledge about, integrated nutrient management practices such as time of application of FYM, time of application of compost and idea about requirement of essential nutrients for crop growth, the knowledge possessed by paddy growers was (59.16%),(56.67%) and 51.17 per cent respectively.

Little more than one fourth (25.33%) of paddy growers had knowledge about green leaf manuring crops while little more than one fifth (21.67%) had knowledge about recommended dose of green leaf manures and only 20.83 per cent paddy growers knew about time of application of green manuring crops.

In case of levels of knowledge of paddy growers, majority of paddy growers (60.83%), were in medium level of knowledge whereas 25.00 per cent paddy growers possessed low level of knowledge with regards to recommended integrated nutrient management practices. Only 14.17 per cent paddy growers possessed high level of knowledge.

Keywords: (Knowledge, integrated nutrient management, FYM, nitrogenous fertilizer, phosphatic fertilizer, green mnuring)

Introduction

Globally, India ranks first in rice area and second in rice production after China. Within the country, rice occupies one-quarter of the total cropped area that contributes about 40 to 43 per cent of total food grain production and continues to play a vital role in the national food. Area under rice cultivation in India was 43.19 million hectares, production of 110.15 million tonnes with productivity of 2550 kg per hectare during 2016-17. In Maharashtra rice is second important crop of the people, which is grown over an area of 1.42 million hectares with an annual rough rice production of 2.66 million tonnes (2017-18). The average productivity of the state is 1.87 tonnes per hectare. Maharashtra ranks 13th place in rice production in country. In Vidarbha region paddy crop is grown mostly in considerable area of about 0.74 million hectares. In Vidarbha region Gadchiroli, Bhandara, Gondia, Chandrapur and some parts of Nagpur and Wardha are the prominent district of paddy cultivation. The area under paddy cultivation in Gadchiroli district is about 1.83 lakh hectares (2018-19). There is need to increase the productivity of paddy for improvement of financial status of farmers.

The reasons for low productivity are fluctuation in the rainfall pattern, improper management of recourses (like soil, water and nutrient management), faulty plant protection techniques and weak extension link denying improved technology to paddy growers who continue to follow traditional methods and also due to improper nutrient management practices in paddy crop.

There are various improved cultivation practices recommended namely, sowing time, seed rate, soil preparation, spacing, seed treatment, varieties, fertilizer application, irrigation, intercultural operations, pest and disease management, harvesting etc. In addition to this, there are certain integrated nutrient management practices which includes use of organic manures, inorganic fertilizers and bio-fertilizers, so as to improve soil fertility and increase soil productivity which is ecologically safe.

Importance of organic manuring in Indian agriculture has been known since ancient times. It is also well known that; bulky organic manures are beneficial in improvement and maintenance of soil productivity. Intensive cropping and use of chemical fertilizer in different parts of world was resulted in the deterioration of soil fertility.

The concept of integrated nutrient management is the continuous improvement of soil productivity on long term basis through appropriate use of fertilizers and organic manures including green manures and their scientific management for optimum growth, yield and quality of different crops and cropping systems in specific agro-ecological situations.

In agriculture, today there is a wide gap between demand (requirement) of nutrients (NPK) for derived food production and supply of nutrients through supplementary and complementary use of organic and biological sources of nutrients in Integrated Nutrient Management systems. The use of organic manures, crop residues, microbial fertilizers and green manuring are all becomes more essential because of limited availability of chemical fertilizer and their higher prizes.

By knowing the importance of integrated nutrient management, it should be adopted by the farmers in judicious manner.

"Adoption is a decision to make full use of an innovation as the best course of action available."

Integrated Nutrient Management consists of the use of both organic manures and inorganic manures and bio-fertilizers, practices that meet current and future societal needs for food, for ecosystem service, for healthy lives and that do so by maximizing the net benefit to society when all costs and benefits of the practices are considered. Thus, for sustainable agriculture integrated nutrient management is must.

Methodology

Locale of the study

The present investigation was carried out in Chamorshi, Armori and Dhanora talukas of Gadchiroli district which is located in eastern Vidarbha region of Maharashtra State. The Gadchiroli district was selected purposively as it is a paddy growing as well as one of the most backward districts in Maharashtra State.

Research Design: An exploratory research design of social research was used in the present study.

Sample and sampling procedure

The sampling plan adopted for this research has been described under subheads

Selection of tahsil and villages

In Gadchiroli district there are total 12 talukas, out of which consecutive three talukas namely Chamorshi, Armori and Dhanora talukas of Gadchiroli were selected on the basis of maximum area under paddy cultivation.

List of paddy growing villages was obtained from Taluka Agriculture officer of the concerned taluka and four villages from each taluka were selected randomly based on maximum area under paddy crop. The selected villages were Wakadi, Mudaza Bk, Shivni, Dongargaon Bk, Kunghada, Bhadbhidi, Talodhi, Navegaon, Karwafa, Khutgaon, Pandharsada, and Chatgaon

Selection of respondents

From each selected village, list of paddy growers was obtained from Talathi of concerned village and 10 paddy growers were selected randomly based on maximum area under paddy crop to constitute sample size of 120 paddy growers from 12 villages of three talukas.

Results and Discussion

Table 1: Distribution of the respondents according to their practice-wise knowledge about integrated nutrient management practices of paddy.

Sr. No.	Particulars	Knowledge	
		Correct	Incorrect
		Frequency (n=120)	
1	Meaning of Integrated Nutrient Management (INM refers to use of organic, inorganic and biological components in integrated manner)	19 (15.83%)	105 (84.17%)
2	Requirement of essential nutrients for crop growth For example: Nitrogen, Phosphorus, Potassium etc.	62 (51.17%)	58 (48.83%)
3	Soil testing (To know the nutrient level in soil)	94 (78.33%)	26 (21.67%)

Sr. No.	Particulars	Knowledge	
		Correct	Incorrect
		Frequency (n=120)	
4	Application of FYM (10-12 t/ha)	84 (70.00%)	36 (30.00%)
5	Time of application of FYM (30-45 days before transplanting)	52 (43.33%)	68 (56.67%)
6	Application of compost (10 t/ha)	35 (29.17%)	85 (70.83%)
7	Time of application of compost (30-45 days before transplanting)	25 (20.83%)	95 (79.17%)
8	Green leaf manuring crops. (Dhaincha, Sunhemp, Boru etc.)	31 (25.33%)	89 (74.67%)
9	Incorporation of green leaf manure @ 6.25 t/ha.	26 (21.67%)	94 (78.33%)
10	Time of application of green leaf manure (At the time of puddling)	25 (20.83%)	95 (79.17%)
11	Recommended dose of nitrogen fertilizers for Paddy crop. (100-120 kg)	101 (84.17%)	19 (15.83%)
12	Time of application of Nitrogenous fertilizers. (50% @Basal dose+ 25% @Tillering stage+ 25% @Panicle emergence)	89 (74.17%)	31 (25.83%)
13	Use of Urea, DAP brickets. (60% urea+40% DAP). @170 brickets/Ha. 5-6 cm below soil surface in between each square of plant.	02 (01.67%)	118 (98.33%)
14	Recommended dose of Phosphatic fertilizers for paddy crop. (50 kg Phosphorus/ha.)	95 (79.17%)	25 (20.83%)
15	Time of application of Phosphatic fertilizers. (At the time of puddling)	91 (75.83%)	29 (24.17%)
16	Recommended dose of Potassium fertilizers for paddy crop. (50 kg Potassium/ha.)	82 (68.33%)	38 (31.67%)
17	Time of application of Potassium fertilizers. (At the time of puddling)	79 (65.83%)	41 (34.17%)
18	Recommended dose of zinc sulphate @10 kg/ha	05 (04.17%)	115 (95.13%)
19	Application of 500 kg of gypsum/ha (as source of Ca and S nutrients) at last ploughing.	03 (02.50%)	117 (97.50%)
20	Seed treatment with biofertilizers: Azotobacter/Azospirillum/Phosphobacteria	12 (10.00%)	108 (90.00%)
21	Application of BGA/Azolla after transplanting.	03 (02.50%)	117 (97.50%)
22	Application of solid $FeSO_4$ (30 kg Fe/ha) to overcome iron deficiency.	02 (01.67%)	118 (98.33%)
23	Application of Boron in soluble forms (borax) for rapid treatment (0.5–3 kg B/ha) to overcome boron deficiency.	05 (04.17%)	115 (95.83%)

Data regarding distribution of the respondents according to their practice-wise knowledge about integrated nutrient management practices of paddy presented in Table 1 It is revealed from Table 1 that, majority of the paddy growers (84.17%) had knowledge about recommended dose of Nitrogenous fertilizers; followed by 79.17 per cent paddy growers who possessed the knowledge about recommended dose of phosphatic fertilizers. A little more than three fourth (78.33%) of the paddy growers had knowledge about soil testing. large majority of the respondents (75.83%),(74.17%) and (70.00%) were having knowledge about time of application of phosphatic fertilizers, time of application of nitrogenous fertilizers and knowledge of application of FYM respectively. It was followed by the paddy growers (68.33%), (65.83%) and (61.67%) having knowledge about recommended dose of potassium fertilizers, time of application of potassium fertilizer and recommended dose of compost respectively.

With regards to knowledge about, integrated nutrient management practices such as time of application of FYM, time of application of compost and idea about requirement of essential nutrients for crop growth, the knowledge possessed by paddy growers was (59.16%),(56.67%) and 51.17 per cent respectively.

Little more than one fourth (25.33%) paddy growers had knowledge about green leaf manuring crops while little more than one fifth (21.67%) had knowledge about recommended dose of green leaf manures and only 20.83 per cent paddy growers knew about time of application of green manuring crops. Also, the knowledge about meaning of Integrated Nutrient Management Practices was possessed by 15.83 per cent paddy growers.

The knowledge possessed by paddy growers about Integrated Nutrient Management Practices such as use of urea+DAP brickets, recommended dose of zinc sulphate and recommended dose of Gypsum was found to be (01.67%), (04.17%) and 02.50 per cent respectively. Very few paddy growers (02.50%), (01.67%), (04.17%) and 10.00 per cent had knowledge about INM practices such as application of BGA/Azolla, application of solid FeSO4, application of Boron and seed treatment with bio-fertilizers respectively.

Table 2: Distribution of the respondents according to their level of knowledge about integrated nutrient management of paddy.

Sr. No.	Knowledge	Respondents (n=120)	
		Frequency	Percentage
1.	Low	30	25.00
2.	Medium	73	60.83
3.	High	17	14.17
	Total	**120**	**100.00**

The data with regards to level of knowledge possessed by the paddy growers about recommended INM practices furnished in Table 2, it is indicates that majority of paddy growers (60.83%), were in medium level of knowledge whereas 25.00 per cent paddy growers possessed low level of knowledge with regards to recommended integrated nutrient management practices. Only 14.17 per cent paddy growers possessed high level of knowledge.

These findings of the present study are in the line with Jayshree Umale (2010), Sagane (2010), Dhenge (2013) and Shambharkar who reported that, majority of respondents had medium level of knowledge.

Conclusion

It can be concluded from the study that, majority of the paddy growers (84.17%) had knowledge about recommended dose of nitrogenous fertilizers followed by 79.17 per cent paddy growers who possessed the knowledge about recommended dose of phosphatic fertilizers. Majority of the respondents (75.83%),(74.17%) and (70.00%) were having knowledge about time of application of phosphatic fertilizers, time of application of nitrogenous fertilizers and knowledge of application of FYM respectively. Little more than one fourth (25.33%) paddy growers had knowledge about green leaf manuring crops. With regards to overall knowledge level of paddy growers about integrated nutrient management practices majority of paddy growers (60.83%), were in medium level of knowledge whereas 25.00 per cent paddy growers possessed low level of knowledge with regards to recommended integrated nutrient management practices. Only 14.17 per cent paddy growers possessed high level of knowledge.

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Morphological Characterization of Diverse Sesame Genotypes

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Abstract: The morphological characterization distinguishing proof and genetic improvement evaluation is most extreme significant input for field functionaries, seed certification agency personals viz., certification officers, seed officers and the entrepreneur engaged in seed production business. Sesame is a member of the family Pedaliaceae and is considered as one of the most ancient oil seed crops, having the great diversity across the India. The goal of this study is to evaluate the major characteristics of fifty-one sesame genotypes collected from all over the locations of India. The purpose of the study is to evaluate the variability available in the sesame. The set of eleven important morphological traits were recorded indicated substantial degree of diversity among the genotypes days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, number of seeds per capsule, length of capsule, 1000 seed weight, seed yield per plant, harvesting index and oil content. The sesame genotypes viz., IC-402056, EC-370343, IC-204049, AKT-101 and IC-203920 found high potential for seed yield, whereas, AKT-101, IC-204037, IC-203920 and EC-370402 for high oil content. Several of the genotypes under investigation were identified as high yielding and potential sources for oil content which to be included in future sesame breeding programs, which can be used for improvement of sesame varieties for the sesame growing areas of Vidarbha.

Keywords : morphological characterization, sesame, seed yield and oil content.

Introduction

Sesame is a flowering plant in the genus Sesamum. Numerous wild relatives occur in Africa and a smaller number in India. It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds, which grow in pods. World production in 2018 was six million tonnes, with Sudan, Myanmar, and India as the largest producers of sesame. Sesame belongs to family Pedaliaceae having chromosome number (2n = 26). Sesame is an annual crop with an erect, pubescent, branching stem and upto 1.20 meter tall. The plants have leaves which are ovate to lanceolate or oblong while the lower leaves are tri-lobed and sometimes ternate, the upper leaves are undivided, irregularly pointed serrate (Felter and Lloyd, 1898) with exceptional multiple branches, in contrast to unbranched (Kinman and Martin, 1954). Sesame grown all over the India, it possess a wide range of variability and had number of distinct forms available all over the country. Sesame is better known as "Queen of oilseeds" by virtue of its quality edible oil and protein content. As it seed contains 50 per cent oil, 23 per cent protein and 15 per cent carbohydrate (Ranganatha *et al.* 2012).

India (North Indian plain and Burma) and Abyssinia is the basic centre of origin and China as a secondary centre of origin for special endemic group of dwarf varieties (Vavilov, 1926). The success of any plant breeding programme depends on the extent of heritable variability existing in the material. Therefore, it is necessary to assess the extent of variation, which can be done through morphological characterization of available set of germplasm.

Material and Methods

The present investigation was conducted as per standard procedure of RBD design in three replicates during *Kharif* season of year 2019 at University Department of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with set of fifty-one sesame genotypes collected from all over sesame growing areas of country. The major morphological traits were identified based on past references which are important for economic yield. Eleven morphological observations were recorded and accordingly the germplasm is grouped into categories viz., high yielding, high oil content etc.

The climate of Akola is subtropical semi-arid characterized by the three distinct season *viz.*, summer becoming hot and dry from March to May, the warm and rainy monsoon from June to October and winter with mild cold form November to February. Akola is situated in the subtropical zone at the latitude of $20^0 42'$ North and longitude of $77^0 02'$ East. Altitude of the place is 307.41 m above the mean sea level.

Average annual precipitation is 750 mm and the major amount is received during the period of June to September. Winter rains are few and uncertain. The normal mean monthly maximum temperature during the hottest month (May) is 46^0C while the normal mean monthly minimum temperature in the coldest month (December) is 10.7^0C. The mean daily evaporation reaches as high as 19.00 mm in the month of may and as low as 3.00 mm in the month of August.

Result and Discussion

The analysis of variance was carried out to assess the variation in the genotype for all quantifiable characters under present investigation. The significance was tested by applying 'F' test, the analysed data indicated that the treatment mean sum of squares found highly significant for all the characters, indicating the presence of substantial genetic variation among the genotypes (Table 1) Similar kind of result were also substantial by Ujjainkar et al., (2002), Jadhav and Mohrir (2012), Bharati *et al.* (2014), Haibru *et al.* (2018) and Singh *et al.* (2018).

Table 1. Analysis of variance for eleven characters in fifty one sesame genotypes

Sr. No.	Characters	Mean Sum of Squares		
		Replications	Genotypes	Error
	Degree of freedom	2	50	100
1	Days to 50% flowering	2.52	795.35**	187.48
2	Days to maturity	6.13	816.01**	153.20
3	Plant height (cm)	188.61	11246.29**	3177.31
4	No. of branches per plant	1.75	85.53**	32.46
5	No. of capsules per plant	19.01	5022.36**	622.25
6	No. of seeds per capsule	29.62	2779.66**	534.24
7	Length of capsule (cm)	0.02	7.88**	1.04
8	1000 seed weight (g)	0.02	18.66**	0.39
9	Seed yield per plant (g)	0.61	116.33**	14.46
10	Oil content (%)	6.72	1362.83**	223.63
11	Harvesting index (%)	66.99	7731.66**	1369.70

*Significance at 5% level, **Significance at 1% level

The germplasm represented the high degree of diversification indicating the high potential for future plant breeding endeavors. The mean performance of fifty one sesame genotypes for eleven characters gives the general view of genotype. Wide ranges of variation were observed in the estimated means of all three replicates of an experiment for all the eleven characters studied in present investigation (Table 2). The comparison of mean performance of fifty one genotypes for eleven traits using mean values of each genotype revealed very high level of variability in the genotypes. Among all fifty one sesame genotypes, the genotype IC-402056 (4.98 g) was recorded highest seed yield per plant followed by EC-370343 (4.86 g), IC-204049 (4.61 g), AKT-101(4.51 g) and IC-203920 (4.39 g).

Table 2. Estimated range for yield and yield contributing characters in sesame

Sr. No.	Characters	Range
1	Days to 50% flowering	37.33 to 46.67
2	Days to maturity	87.00 to 99.00
3	Plant height (cm)	89.00 to 127.87
4	Number of branches per plant	1.87 to 5.47
5	Number of capsule per plant	15.73 to 38.53
6	Number of seeds per capsule	52.53 to 70.13
7	Length of capsule (cm)	2.03 to 2.93
8	1000 seed weight (g)	2.09 to 3.55
9	Seed yield per plant (g)	1.71 to 4.98
10	Harvesting index (%)	13.64 to 40.88
11	Oil content (%)	39.06 to 50.96

The earliest days to 50 per cent flowering were recorded for genotype EC-370364 (37.33 days) followed by IC-204065 (37.67 days) and EC-370344 (38.33 days) while, the earliest days to maturity of 87 days were recorded by IC-204041 and EC-370346. Short status of plant height was recorded for the genotype TKG-15-01 (89.00 cm) which was identified as dwarf genotype. The highest branching ability (5.47) among all the genotypes were recorded by EC-370373; IC-204062 followed by

(5.33) branches exhibited in EC-370402 and ES-46-1. The maximum number of capsules per plant recorded by genotypes IC-402056 (38.53) and IC-204055 (36.67). While genotype AKT-101(70.13) was recorded the maximum number of seeds per capsule.

The genotypes TKG-478 (2.93 cm), EC-370368 (2.90 cm) and TKG-15-2-1 (2.89cm) has maximum length of capsule. Maximum 1000 seed weight was recorded for genotype JLS-709-1 (3.55 g), TKG-523 (3.50 g) and EC-370343 (3.42 g). Among all the genotypes, the genotypes IC-204056 (40.88%) and EC-370343 (40.08%) recorded the maximum harvesting index while, the genotypes AKT-101 (50.96%) had exhibited the highest oil content followed by IC-204037 (50.05%) and IC-203920 (50.02%) which is statistically at par.

The presence of genetic variability in available genepool provides an opportunity for selecting superior genotypes, which can be obtained through vigorous screening and evaluation. Selection of superior genotypes based on yield alone would be ineffective. In order to make the selection criteria one has to put attention on yield contributing traits, which contribute yield in positive direction. The knowledge of association between the characters and their direct and indirect contribution towards expression of seed yield will be of an additional help to plant breeders in deciding the selection criteria.

As the *per se* performance cannot be the only criteria for selection programme as the values of parent may not be noted in progeny, but it's provide the foundation for planning the future breeding programe. Although there is need of further analysis at genetic level so that the perfect prediction of genetic potential of these genotypes can be done as reported by many workers viz., Ujjainkar et al (2002), Sivaprasad *et al.* (2013), Bharati *et al.* (2014) and Swapan *et al.* (2016)

Conclusion

It could be concluded from present investigation that the morphological evaluation is prime step for judging the potential of gentoypes. The sesame genotypes under present investigation viz., IC-402056, EC-370343, IC-204049, AKT-101 and IC-203920 found high potential for seed yield, whereas, AKT-101, IC-204037, IC-203920 and EC-370402 for high oil content which can be utilized as a parent in hybridization programs or can be future promoted as variety in this region.

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A Promising Hybrid in Sunflower: PDKVSH 964

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Abstract: Sunflower (*Helianthus annuus L.*) is the second after the maize being cultivated as hybrid crop. Hybrid crop was found superior to the open pollinated and synthetic varieties due to superiority in yield potential and uniformity in maturity. The hybrid vigor and heterozygous genetic base of the hybrids allow them to show better yield than synthetic varieties even under stress condition. The superior performance of hybrid was due to manifestation of heterosis. The experiment was carried out at different regions of Maharashtra during kharif seasons from 2016 to 2019 in Randomized Block Design with three checks (PDKVSH 952, LSFH 171 and DRSH -1). This study illustrated that, the seed yield in the University Multilocation Hybrid Trial the Sunflower hybrid PDKVSH 964 was found superior by 36.5%, 22.3% and 18.7% for seed yield over existing check LSFH 171, PDKVSH 952 and DRSH 1 respectively. For Vidarbha region in the State Hybrid Trial, the hybrid PDKVSH-964 recorded 40.9% increase over LSFH 171, 25.1% increases over PDKVSH 952 and 22.2% increases over DRSH 1.For overall Maharashtra in the State Hybrid Trial, the hybrid PDKVSH 964 recorded superiority by 22.21%, 21.05% and 12.09% for seed yield over existing check PDKVSH 952, DRSH 1 and LSFH 171 respectively.

While the oil yield in the University Multilocation Hybrid Trial, the hybrid PDKVSH 964 recorded 49.9% increase over LSFH 171, 34.2% increase over PDKVSH 952 and 26.7% increase over DRSH 1. For Vidarbha region in the State Hybrid Trial, the hybrid PDKVSH-964 recorded 41.8% increase over check LSFH 171, 25.5% increases over check PDKVSH 952 and 16.3% increase over DRSH 1. For overall Maharashtra in State Hybrid Trial, the hybrid PDKVSH 964 recorded 29.20% increases over PDKVSH 952, 24.38% increases over LSFH 171 and 17.84% increases over DRSH 1. PDKVSH 964 matures in 89-90 days which belong to medium duration group. PDKVSH 964 moderately resistant to *Alternaria* disesase and leaf hopper pest. Overall superior seed and oil yield performance of sunflower hybrid PKVSH 964 in different trials, this hybrid is considered as promising sunflower hybrid for cultivation in Vidarbha region of Maharashtra.

Keywords: Sunflower, Hybrid, PDKVSH 964

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most important edible oilseed crops of the world and it accounts for nearly 14% of the global production of 9 major vegetable oilseed crops. Sunflower contains 38 to 42% edible oil high level of linoleic acid (55 – 60%) and low oleic acid (25 – 30%).). The Sunflower oil also contains 25% proteins, 30% carbohydrates and about 4% ash. The sunflower oil contains 20-25% essential vitamins such as A, D, E and K (Satyabrataet al, 1988).

Sunflower (*Helianthus annuus L.*) is the second after the maize being cultivated as hybrid crop. Hybridsare found superior to the open pollinated and synthetic varieties due to their superiority in yield potential and uniformity in maturity. The hybrid vigor and heterozygous genetic base of the hybrids allow them to show better yield than synthetic varieties even under stress conditions. The superior performance of hybrid is due to manifestation of heterosis.

Despite phenomenal growth rate in area expansion, the productivity of sunflower crop in India has remained low. The rainfed cultivation, biotic and abiotic stresses and poor quality seed are some of the important factors responsible for low productivity. In coming years, major emphasis is to be placed on increasing productivity and yield stability across environments. This necessitates to develop new hybrids with high seed yield and inbuilt resistance to biotic and abiotic stresses. Therefore theefforts were made in that direction and PDKVSH 964, a highyielding and medium duration sunflower hybrid is pre released for commercial cultivation in Vidarbha region of Maharashtra.

Material and Methods

PDKVSH 964 hybrid (Figure 1) was developed by utilizing male sterile line ARM 249A as female and monohead population AKSF 14R as a male line with the objectives of high yield and medium maturity duration.

The hybrid PDKVSH 964 along with other hybrids was tested to evaluate its yield potential across locations and seasons Multilocaton Hybrid Trial (MHT) at six locations andState Hybrid Trial (SHT) at eight locations along with other 10-12 entries were conducted during *kharif* seasons from 2016 to 2019 in Randomized Block Design with three checks (PDKVSH 952, LSFH 171 and DRSH -1). The net plot size adopted was 1.8 m x 3.9 m (3 Rows) and spacing of 60 cm x 30 cm. Every year at all locations the crop was sownin the 2nd fortnight of July under rainfed conditions and common dose of fertilizer 80:60:30 NPK kg ha-1 was applied. Recommended agronomic packages of practices were followed to raise healthy crop.

Table 1: Performance of sunflower hybrid PDKVSH 964 in Preliminary Hybrid Trial

Sr. No.	Hybrid entries	Seed yield (kg ha-1)	Oil content (%)	Oil yield (kg ha-1)
1	PDKVSH 964	1331	39.27	522.59
2	DRSH-1 (C)	1244	39.34	489.56
3	LSFH-171 (C)	952	35.03	333.68
4	PDKVSH-952 (C)	1221	36.80	449.59
	SE ±	**80.82**		
	CD at 5%	**230.36**		
	CV	**12.66**		

Table 2: Performance of sunflower hybrid PDKVSH 964 in Multilocation Hybrid Trial and State Hybrid Trial -Seed yield (kg ha-1)

Sr. No.	Trial	Year of testing	No. of locations	PDKVSH 964	PDKVSH 952 (C)	LSFH 171 (C)	DRSH-1 (C)
A	**University Trial -MHT**						
	Weighted Mean	Kh. 2016-17	10	2228	1822	1632	1877
	% increase				**22.3**	**36.5**	**18.7**
B	**State Trial (Vidarbha locations) SHT**						
	Weighted Mean	Kh. 2016-19	15	2247	1796	1595	1839
	% increase				**25.1**	**40.9**	**22.2**
C	**State Trial (Overall Maharashtra locations) SHT**						
	Weighted Mean	Kh. 2016-19	29	1850	1514	1651	1529
	% increase				**22.21**	**12.09**	**21.05**

Table 3: Performance of sunflower hybrid PDKVSH 964 in Multilocation Hybrid Trial and State Hybrid Trial-Oil yield (kg ha-1)

Sr. No.	Trial	Year of testing	No. of locations	PDKVSH 964	PDKVSH 952 (C)	LSFH 171 (C)	DRSH-1 (C)
A	**University Trial**						
	Weighted Mean	Kh. 2016-17	4	794	592	529	627
	% increase				**34.2**	**49.9**	**26.7**
B	**State Trial (Overall Vidarbha locations)**						
	Weighted Mean	Kh. 2016-19	6	809	644	570	695
	% increase				**25.5**	**41.8**	**16.3**
C	**State Trial (Overall Maharashtra locations)**						
	Weighted Mean	Kh. 2016-19	9	722	559	581	613
	% increase				**29.20**	**24.38**	**17.84**

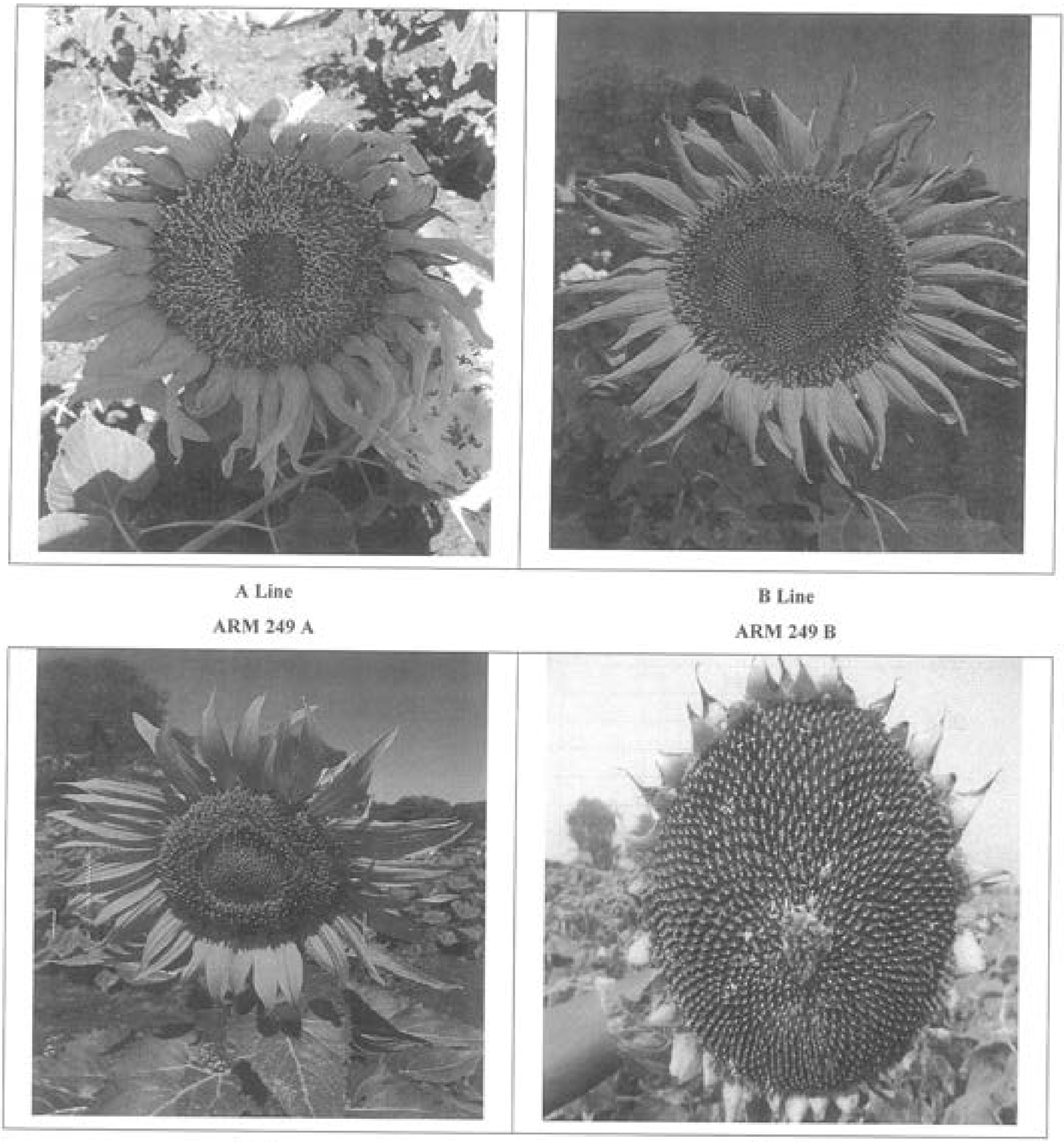
Table 4 (A) : Reaction of proposed hybrid PDKVSH - 964 to *Alternaria* in Multilocation Hybrid and State Hybrid screening trial

	Year	Genotype	Scale grade (0 -9)	Reaction
PHT	2015	**PDKVSH-964**	**3**	**MR**
		PDKVSH-952 (C)	3	MR
		LSFH 171 (C)	3	MR
		DRSH 1 (C)	3	MR

	Year	Genotype	Scale grade (0 -9)	Reaction
PHT	2015	**PDKVSH-964**	**3**	**MR**
		PDKVSH-952 (C)	3	MR
		LSFH 171 (C)	3	MR
		DRSH 1 (C)	3	MR
MHT	2016	**PDKVSH-964**	**3**	**MR**
		PDKVSH-952 (C)	3	MR
		LSFH 171 (C)	3	MR
		DRSH 1 (C)	-	-
SHT	2017	**PDKVSH-964**	**5**	**MS**
		PDKVSH-952 (C)	5	MS
		LSFH 171 (C)	5	MS
		DRSH 1 (C)	5	MS
	2018	**PDKVSH-964**	**3**	**MR**
		PDKVSH-952 (C)	3	MR
		LSFH 171 (C)	1	R
		DRSH 1 (C)	3	MR
	2019	**PDKVSH-964**	3	**MR**
		PDKVSH-952 (C)	3	MR
		LSFH 171 (C)	3	MR
		DRSH 1 (C)	3	MR

Table 4 (B) : Reaction of proposed hybrid PDKVSH - 964 to leaf hoppers in State Hybrid screening trial

Year	Genotype	Scale grade (0-5)	Reaction
2016	**PDKVSH-964**	**2**	MR
	PDKVSH-952 (C)	2	MR
	LSFH 171 (C)	2	MR
	DRSH 1 (C)	2	MR
2017	**PDKVSH-964**	**1.2**	**MR**
	PDKVSH-952 (C)	1.6	MR
	LSFH 171 (C)	1.8	MR
	DRSH 1 (C)	2.0	MR
2018	**PDKVSH-964**	**1.4**	**MR**
	PDKVSH-952 (C)	1.6	MR
	LSFH 171 (C)	1.4	MR
	DRSH 1 (C)	1.8	MR
2019	**PDKVSH-964**	**1.5**	**MR**
	PDKVSH-952 (C)	1.6	MR
	LSFH 171 (C)	1.5	MR
	DRSH 1 (C)	1.4	MR



A Line
ARM 249 A

B Line
ARM 249 B

Line
AKSF 14R

Hybrid
PDKVSH 964

Figure 1: PDKVSH 964 and it's Parents

Results And Discussion

The yield potential of PDKVSH 964 hybrid was confirmed at Oilseeds Research Unit, Dr. PDKV, Akola in Preliminary Hybrid Trial (PHT) during *Kharif* 2015. On that basis of per se performance, it was promoted in Multilocaton Hybrid Trial (MHT) and also in State Hybrid Trial (SHT) during *Kharif* 2016. It has been proved superior in performance for seed yield (1331 kg ha^{-1}) over the checks DRSH-1 (1224 kg ha^{-1}), PDKVSH 952 (1221 kg ha^{-1}) and LSFH 171 (952 kg ha^{-1}). Similarly, it has recorded 522 kg ha^{-1} oil yield (Table 1).

The seed yield in the University Multilocation Hybrid Trial the Sunflower hybrid PDKVSH 964 was found superior by 36.5%, 22.3% and 18.7% over the existing checks LSFH 171, PDKVSH 952 and DRSH 1 respectively (Table 2).

For Vidarbha region in the State Hybrid Trial, this hybrid PDKVSH-964 recorded 40.9% increase over LSFH 171, 25.1% increases over PDKVSH 952 and 22.2% increases over DRSH 1.For overall Maharashtra in the State Hybrid Trial, the hybrid PDKVSH 964 recorded superiority by 22.21%, 21.05% and 12.09% for seed yield over existing checks PDKVSH 952, DRSH 1 and LSFH 171 respectively (Table 2).

Similarly, the oil yield of this hybrid was also superior as compared to the check hybrids. In the University Multilocation Hybrid Trial, the hybrid PDKVSH 964 recorded 49.9% increase over LSFH 171, 34.2% increase over PDKVSH 952 and 26.7% increase over DRSH 1. For Vidarbha region in the State Hybrid Trial, the hybrid PDKVSH-964 recorded 41.8% increase over check LSFH 171, 25.5% increases over check PDKVSH 952 and 16.3% increase over DRSH 1.For overall Maharashtra in State Hybrid Trial, the hybrid PDKVSH 964 recorded 29.20% increases over PDKVSH 952, 24.38% increases over LSFH 171 and 17.84% increases over DRSH 1 (Table 3).

PDKVSH 964 hybrid matures in 89-90 days, which belongs to medium duration group and also moderately resistant to *Alternaria* disesase and leaf hopper pest (Table 4 A & B).

Conclusion

Considering the overall superior seed and oil yield performance of this sunflower hybrid PKVSH 964 in different trials over the seasons, this hybrid seems to be promising sunflower hybrid for cultivation in Vidarbha region of Maharashtra.

Implication

In view of superiority of this sunflower hybrid PDKVSH 964, it has been pre released during 2020 and can be released for the benefit of the farmers of Vidarbha region of Maharashtra state.

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Farming Systems : Scope of Doubling Farming Income

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Abstract: This study also attempts to analyse the existing farming systems and develop efficient farming system for increasing and stabilizing the farm income and employment. This will help the planners and policy makers in formulating policy packages and plan of action for increasing and stabilizing farm income of individual farmers.

The study was conducted in three tahsils viz. Akola , Balapur , Murtizapur in Akola district and analyzing the economics of selected farming systems, income and employment pattern of farming systems. The primary data were collected for the year 2014-15. Twenty farmers from each tahsil were selected randomly, there by, making a total sample size of 60 respondents.

The major five adopted farming systems selected for study i.e. Agriculture farming system, Agri + Horti farming system, Agri +Dairy farming system, Agri +Poultry farming system and Agri + Goat farming system.

The study revealed that the B:C ratio of Agriculture + Dairy system i.e 1.46 highest followed by Agri. + Poultry (1.43) and Agri + Goat (1.41), farming system.

The per farm total income of Agri + Dairy farming system was higher i.e. Rs. 131943.52 , followed by Agri +Goat(Rs. 129108.28), Agri +Horti (Rs. 117303.49) farming system.

The total own farm employment was more in Agri + Dairy i.e. 234.42 days(64.22 %) followed by Agriculture + Goat i.e. 220.02 days(60.27 %) farming system. In all the farming systems owned and hired male- female played significant activity as compared to other activities of production. The farmers can realize the doubling of their income, it is possible only the contribution of different combinations of enterprises such as Agri. + Dairy, Agri. + Goat, Agri. + Poultry and Agri + Horticulture in the farming system.

Keywords: Farming system, doubling farmers' income.

Introduction

In India, the farmers maintain different enterprises for their complimentary and supplementary nature and for ensuring sustainable livelihood from time immemorial. After the advent of green revolution in late-1960s and economic liberalization in early-1990s, the farmers gradually started focusing on a few enterprises due to several imposing factors including shrinking farm sizes, fluctuating commodity prices, livelihood diversification and shortage of labour during peak agriculture season. It had a severe impact on food and nutritional security of millions of poor farm households. The anguish of farmers is often expressed in terms of their agitation in one or the other part of the country, unwillingness to continue farming and increasing demands of compensating their economic loss. Although suggestions are pouring in from experts and leaders of organisation for strengthening the income base of farmers, the government cannot implement them entirely due to compulsions from socio-economic and political considerations. However, the Government of India has made an announcement about Doubling Farmers' Income by 2022. Experts are judging the options and strategies for achieving this enviable target. One of the options is to evaluate the potential of age-old integrated farming system (IFS) in enhancing income of farm families within the reasonable time period. This paper deals with dairy, Goat, Poultry & Horticultural crop based enterprise combinations for their contribution to sustainable livelihood of farm families with income enhancement as a major plank.

Farming system is a complex inter-related set of elements containing crops, dairy, poultry, fish, sericulture, vermin-compost, sheep and goats, etc. which interact among themselves. The judicious mix of the crops and animal enterprises must be based on the principle of minimizing the competition for resources and maximizing the complimentarily of returns among the enterprises. Farm as a unit is to be considered and planned for effective integration of enterprises to be combined with crop activity. An economic assessment of farming system aims at finding the magnitude of profits from each components of the farming systems and assessing the capacity to utilize the locally available resources, keeping in view the family needs and challenges is carried out in one way rather than another.

This study also attempts to analyse the existing farming systems and develop efficient farming system for increasing and stabilizing the farm income and employment. This will help the planners and policy makers in formulating policy packages and plan of action for increasing and stabilizing farm income of individual farmers.

Objectives

1. To identify the existing farming systems in Akola district.
2. To study income and employment pattern in different farming systems.

Methodology

The study was based on primary data. Three tahsils of Akola district were selected namely Akola, Murtizapur and Balapur. Twelve sample of each farming system were collected randamly. The primary data of 60 farmers were collected from these three tahsils randomly. The necessary information of selected farming systems was collected by survey method in prescribed schedules for the year 2014-2015.

From existing farming systems we select following five farming systems.

	Farming Systems	Sample size
1.	Agriculture Farming System	12
2.	Agriculture + Dairy Farming	12
3.	Agriculture + Poultry Farming	12
4.	Agriculture + Goat Farming	12
5.	Agriculture + Horticulture	12

Benefit – Cost Ratio Analysis

The probability of crop production cannot be justified completely unless benefit cost ratio was worked out. This is the ratio which represents return obtained per rupee of investment . It is worked out by dividing gross return by the total cost.

$$\text{B : C ratio} = \frac{\text{Gross return}}{\text{Total cost}}$$

Results and Discussion

Economics of selected farming systems:

The five farming systems identified as major farming systems across the study area, irrespective of the district are compared with respect to their returns generating capacity, costs involved, net returns and benefit cost ratio.

Table 1 : Economics of selected farming systems

(Rs/ha)

Sr. No.	Particulars	Costs			Returns		
		Total variable cost	Total fixed cost	Total cost	Gross returns	Net returns	B:C ratio
1	Agriculture	135857.64	17813.42	153671.06	194781.14	41110.08	1.27
5	Agriculture + Horticulture	188412.97	19504.56	207917.53	278530.66	70613.13	1.34
2	Agriculture + Dairy	202949.87	18502.5	221452.37	323004.87	101552.5	1.46
3	Agriculture + Poultry	110583.66	16500.75	127084.41	181656.16	54571.75	1.43
4	Agriculture + Goat	191096.5	17800.5	208897.00	294066.16	85169.16	1.41

From the table 1, it is revealed that the per hectare total variable cost was the highest in Agri + Dairy farming system i.e Rs. 202949.87 followed by Agri + Goat i.e RS. 191096.5 and Agri + Horti farming system, Rs. 188412.97. The total fixed cost was observed highest in Agri + Horti farming system i.e Rs. 19504.56 followed by Agri + Dairy farming system, i.e Rs. 18502.5. Among the systems, the highest per hectare gross return was observed in Agri + Dairy farming system i.e Rs. 323004.87, followed by Agri + Goat farming system i.e Rs. 294066.16.

The B:C ratio was the highest in Agriculture + Dairy system i.e 1.46 followed by Agri. + Poultry farming system i.e 1.45 and Agri + Goat, farming system i.e 1.41.

The selected farming systems the farmers practicing Agri + Dairy farming system have fetches highest returns. It is suggested that to improve the economic condition of selected farmers, they should establish dairy unit as subsidiary occupation in addition to crops.

Income pattern of sample farms

The details of source wise income of sample farms in different farming systems is presented in Table 2.

In Agriculture farming system i.e. Agriculture, Agri. + Horti, Agri +Dairy, Agri + Poultry and Agri. + Goat the total income of sample farm were Rs.67370.31, Rs. 117303.49, Rs. 131943.52, Rs.80570.40 and Rs. 129108.28 respectively.

Agri + Horticulture farming system, it was observed that out of the total income, 47.86 per cent income came from crop production, while 52.14 per cent income was from horticulture; the income derived from horticulture was more than agriculture enterprise.

Agri + Dairy farming system was observed that out of the total income, 48.71 per cent income came from crop production, while 51.29 per cent income was from dairy enterprise. Higher income was from Dairy business activity owing to combined effect of crop production activity with dairy enterprise.

Agri + Poultry farming system was observed that out of the total income, 47.93 per cent income came from crop production , while 52.07 per cent income was from poultry enterprise. Higher income was from Poultry business activity owing to combined effect of crop production activity with poultry enterprise, and overall income derived from poultry was more than agriculture enterprise.

In Agri + Goat farming system, it was observed that out of the total income, 47.39 per cent income came from crop production, while 52.61 per cent income was from goat enterprise. Higher income was from farm business activity owing to combined effect of crop production activity with goat enterprise.

Table: 2: Per farm income pattern of farmers

Sr. No	Particulars	Farming System I (Agriculture)	Farming system II (Agri. +Hort)	Farming system III (Agri. + Dairy)	Farming system IV (Agri. + Poulry)	Farming system V (Agri.+ Goat)
1	Crop Production	67370.31 (100.00)	56144.06 (47.86)	64264.85 (48.71)	38619.68 (47.93)	61188.48 (47.39)
2	Horticulture	–	61159.43 (52.14)	–	–	–
3	Dairy	–	–	67678.67 (51.29)	–	–
4	Poultry	–	–	–	41950.72 52.07	–
5	Goat	–	–	–	–	67919.8 (52.61)
Farm business income		67370.31 (100.00)	117303.49 (100.00)	131943.52 (100.00)	80570.4 (100.00)	129108.28 (100.00)

(Note: Figures in the parentheses are the percentage to the total)

Employment pattern on sample farm

The details of source wise employment pattern of the per farm and per hectare of male and female workers in different farming systems is presented in Table 3.

At the overall level, irrespective region, the total own farm employment generated was 113.45, 141.53, 234.42, 137.29 and 220.02 man days in Agriculture farming system, Agri + Horticulture, Agri + Dairy, Agri + Poultry and Agri + Goat farming system respectively. This indicated that farmers of agriculture farming system and poultry farming, do not get adequate employment in crop production and poultry activity throughout the year ,they get just 31.07 per cent and 38.56 per cent employment out of the 365 days of the year respectively. Therefore, farmers require to find the employment in alternative activities in order to earn additional income. Out of the total employment generated in agriculture farming system , 95.24 per cent employment was generated through crop production activity and 4.76 per cent through livestock activity, but in Agri + Horticulture farming system 63.30 per cent employment was generated through crop production activity and 36.69 per cent employment through horticulture enterprise.

While in Agri + Dairy farming , 35.18 per cent employment was generated through dairy activity and 64.82 per cent through crop production activity. In Agri + Poultry farming system, 63.67 per cent employment was generated through crop production activity and 36.33 per cent employment through poultry activity which was much more less than other enterprises. In Agri + Goat farming system, 59.39 per cent employment was generated through crop production activity and 40.61 per cent through goat enterprise.

The total own farm employment was more in Agri + Dairy i.e. 234.42 days(64.22 %) followed by Agriculture + Goat i.e. 220.02 days(60.27 %) farming system in throughout year.

In all the farming systems owned and hired male –female played significant role in crop production activity as compared to other activities of production.

Table 3: Per farm employment pattern on sample farm (man days)

S.N.	Particulars		Farming System I	Farming system II	Farming system III	Farming system IV	Farming system V
			(Agriculture)	(Agri. +Hort)	(Agri. + Dairy)	(Agri. + Poultry)	(Agri.+ Goat)
1	**Crop production**						
	a.Male	Owned	63.38	56.88	75.8	40.48	70.47
		Hired	32.43	27.28	41.005	24.8	35.84
	b.Female	Owned	40.81	31.73	47.05	30.18	31.56
		Hired	48.8	41.29	41.76	21.3	34.69
	Sub Total		185.42	157.18	205.615	116.76	172.56
			(95.24)	(63.30)	(64.82)	(63.67)	(59.39)
2	**Horticulture**						
	a.Male	Owned	–	35.41	–		–
		Hired	–	25.89	–		–
	b.Female	Owned	–	17.51	–		–
		Hired	–	12.31	–		
	Sub Total		–	91.12 (36.70)	–	–	
3	**Dairy**					–	
	a.Male	Owned	7.45	–	95	–	
	b.Female	Owned	1.81	–	16.57		
	Sub Total		9.26		111.57		
			(4.76)		(35.18)		
4	**Poultry**						
	a.Male	Owned				46.13	
	b.Female	Owned				20.5	
	Sub Total					66.63	
						(36.33)	
5	**Goat**						
	a.Male						105.5
	b.Female						12.49
	Sub Total						117.99
							(40.61)
	Total						

S.N.	Particulars		Farming System I	Farming system II	Farming system III	Farming system IV	Farming system V
			(Agriculture)	(Agri. +Hort)	(Agri. + Dairy)	(Agri. + Poultry)	(Agri.+ Goat)
	a. Male	Owned	70.83	92.29	170.8	86.61	175.97
		Hired	32.43	53.17	41.005	24.8	35.84
	b. Female	Owned	42.62	49.24	63.62	50.68	44.05
		Hired	48.8	53.6	41.76	21.3	34.69
	Sub Total		194.68	248.3	317.185	183.39	290.55
			(100)	(100)	(100)	(100)	(100)
	Total own farm Employment throughout year	**1 Year: 365 days**	113.45	141.53	234.42	137.29	220.02
	Percentage of own farm Employment throughout year	**1 Year: 365 days**	**31.08**	**38.77**	**64.22**	**38.56**	**60.27**

(Note: Figures in the parentheses are the percentage to the total)

Conclusion

1. The benefit cost ratio of Agriculture farming system as a whole was 1.27, Agri + Dairy farming system was 1.46, Agri + Horti farming system was 1.34, Agri + Poultry was 1.43 and Agri + Goat i.e 1.41 .
2. The B:C ratio of Agriculture was highest i.e 1.46 followed by Agri + Poultry farming system i.e 1.43 and Agri + Goat farming system i.e 1.41.
3. The total own farm employment generated was 113.45, 141.53, 234.42, 137.29 and 220.02 man days in Agriculture farming system, Agri + Horti, Agri + Dairy, Agri + Poultry and Agri + Goat farming system respectively.
4. In Agri + Horticulture farming system 63.30 per cent employment was generated through crop production activity and 36.70 per cent employment through horticulture enterprise.
5. In Agri + Dairy farming , 35.18 per cent employment was generated through dairy activity and 64.82 per cent through crop production activity.
6. In Agri + poultry farming system, 63.67 per cent employment was generated through crop production activity and 36.33 per cent employment through poultry activity which was much more less than other enterprises.
7. In Agri + Goat farming system, 59.39 per cent employment was generated through crop production activity and 40.61 per cent through goat enterprise.
8. Per Farm income of sample farm worked out to Rs.67370.31, Rs. 117303.49, Rs. 131943.52, Rs.80570.40 and Rs. 129108.28 in Agriculture farming system, Agri + Horti, Agri +Dairy, Agri + Poultry and Agri + Goat farming system respectively.
9. In Agri + Horti farming system, of the total income, 47.36 per cent income came from crop production, 52.14 per cent income was from horticulture, overall income derived from horticulture was more than agriculture enterprise.
10. In Agri + Dairy farming system, of the total income, 48.71 per cent income came from crop production, while 51.29 per cent income from dairy enterprise.
11. In Agri + Poultry farming system, of the total income, 47.93 per cent income came from crop production, while 52.07 per cent income was from poultry enterprise; income derived from poultry was more than agriculture enterprise.
12. In Agri + Goat farming system, of the total income, 47.39 per cent income came from crop production, while 52.61 per cent income was from goat enterprise. Higher income was from farm business activity owing to combined effect of crop production activity with goat enterprise.

13. The total own farm employment was more in Agri + Dairy i.e. 234.42 days(64.22 %) followed by Agriculture + Goat i.e. 220.02 days(60.27 %) farming system in throughout year.

The farmers can realize the doubling of their income by adding Diary, Poultry and Goat the farming system. Diary, Poultry and Goat component would provide the facilitating inputs to change the income of farm families with in a short period.

Policy Implications

1. There is ample scope for increasing the farm income in Agriculture farming system by adopting Dairy enterprise along with field crops.
2. System mode of production incorporating crop,livestock, Goat, Poultry & is a potential option for doubling farmer's income.

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Genetic Parameters Studies in Valencia Groundnut (*Arachis hypogaea* L.*var fastigiata*) for Yield and Component Traits

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Abstract: The present investigation on estimation of genetic parameters in Valencia groundnut was carried out at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the summer 2019-20. The experimental material consists of 24 valencia genotypes and the experiment was laid down in randomized block design. Observations were recorded on five randomly selected competitive plants for various 14 traits. Analysis of Variance indicated that the presence of substantial amount of genetic variability in the genotypes for all the characters. The GCV and PCV were of high magnitude for the character kernel yield per plant (33.25%) followed by pod yield per plant (29.08%), harvest index (24.32%), hundred kernel weight (24.26%), number of pods per plant (22.59). The magnitude of PCV was higher than GCV for all the characters, suggesting the role of environmental variance. Most of the characters under study recorded high heritability indicating. High heritability has been noticed for kernel yield per plant (97.60%), shelling outturn per cent (96.40%), hundred pod weight (96.30%), hundred kernel weight (94.60%), harvest index (94.20%), reproductive efficiency (EF_2) (93.60%), number of secondary branches per plant (92.70%), number of pods per plant (91.40%), days to maturity (90.10%) indicated the presence of lesser environmental influence and prevalence of additive gene action in their expression and suggesting the distinct possibility of improving these traits through selection. Expected genetic advance is the parameter, which indicates the progress that can be expected in a character. High genetic advance was recorded for hundred pod weight followed by hundred kernel weight, harvest index, reproductive efficiency (EF_2), reproductive efficiency (EF_1), shelling outturn indicating these characters are governed by additive genes and selection will be rewarding for improvement of these characters.

Keywords: Groundnut, pod yield, GCV, PCV, heritability

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops grown for variety of purposes. Is grown in about 4.81 m ha with a production of 6.69 m tones to the oilseed basket.The average yield of groundnut in India has 1393 kg/ha. It contains 44 to 51 % oil and 22 to 30 % protein on dry seed basis and is a rich source of minerals like phosphorous, calcium, magnesium, potassium and vitamins such as E, K and B groups. It is cultivated for cheap source of vegetable oil, good quality feedstuff, improvement of soil health through nitrogen fixation as well as a source of fuel for the rural population. Groundnut is mostly cultivated under rainfed condition in India.Although in various states of India, groundnut is cultivated in one or more (*kharif, rabi* and *summer*) season. Breeding high yielding varieties of crop require information on the nature and magnitude of variation in the available materials. Pod yield is a complex character, which is largely influenced by environment. Hence for improving selection and yield levels in groundnut study of genetic variability and heritable variation has been carried out.

Materials and Methods

A field experiment was conducted with 24 groundnut genotypes in Randomized Block Design with three replications in *summer*, 2019 at Oilseeds Research Unit, Dr. PDKV, Akola. The sowing was carried out at the spacing of 30 cm and 10 cm between the rows and plant, respectively with dibbling as a method of sowing. Recommended all agronomic practices were followed to raise a healthy crop. The observations on 16 different traits were recorded with five randomly selected plants from each genotypes for all the replications for pod yield and yield contributing characters viz., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of pods per plant, biomass per plant (g), hundred pod weight (g), hundred kernel weight (g), shelling outturn (%), pod yield per plant (g), kernel yield per plant (g), Oil content (%), reproductive efficiency (EF_1) (%), reproductive efficiency (EF_2) (%), harvest Index (%). The observations obtained in respect of above characters were subjected to analysis of variance and calculation of variability components. The analysis was based on the model suggested by Panse and Sukhatme (1957) and the phenotypic and genotypic components of variances based on analysis of variance were estimated as per the formula suggested by Burton (1952).

Results and Discussion

Analysis of variances recorded significant differences among genotypes for all the characters indicating the presence of considerable amount of variability. The genotypic and phenotypic variances were calculated using respective mean square values from the variance table. There was a closer correspondence between GCV and PCV (Table 1) for all the traits indicated that most of the characters were largely under genetic control. The PCV values were greater than GCV for all the characters such similar findings by Ladole *et al.*, (2009) and Wadikar *et al.*, (2018). Higher GCV and PCV values observed for kernel yield per plant (33.25% and 33.67%) followed by pod yield per plant (29.08% and 29.54%), harvest index (24.32% and 25.05%), hundred kernel weight (24.26% and 24.95%) and number of pods per plant (22.59% and 23.63%) indicating good amount of variation for these characters. These results are confirmative with the findings of Choudhary *et al.* (2013), Kadam *et al.* (2018), Omina *et al.* (2018), Hampannavar *et al.* (2018), Devi *et al.* (2019). Heritability estimates provides information about the variation attributes due to additive genetic effect and the phenotype strongly reflects the genotype. In the present study most of the characters recorded high heritability indicating that these characters were less influenced by environment. High heritability has been noticed for kernel yield per plant (97.60%), podyield per plant (96.90%), shelling outturn per cent (96.40%), hundred pod weight (96.30%), hundred kernel weight (94.60%), harvest index (94.20%), reproductive efficiency (EF_2) (93.60%), number of secondary branches per plant (92.70%), number of pods per plant (91.40%), days to maturity (90.10%) indicated the presence of lesser environmental influence and prevalence of additive gene action in their expression and suggesting the distinct possibility of improving these traits through selection would be effective. These results are in accordance with earlier reports of Patil *et al.* (2015), Wadikar *et al.* (2018), Omina *et al.* (2018), Roy *et al.* (2018), Pachauri and Shikarvar (2019). Expected genetic advance is the parameter, which indicate the progress that can be expected in a character. High genetic advance was recorded for hundred pod weight followed by hundred kernel weight, harvest index, reproductive efficiency (EF_2), reproductive efficiency (EF_1), shelling outturn indicating these characters are governed by additive genes and selection will be rewarding for improvement of these characters. The findings of similar nature in groundnut were reported by Wani *et al.* (2004), John *et al.* (2009) and Sonone *et al.* (2011), Zaman *et al.* (2011). Days to maturity, days to 50 % flowering, number of pods per plant, pod yield per plant, biomass per plant, plant height, kernel yield per plant, oil content showed moderate genetic advance. Low genetic advance was reported for number of primary branches per plant followed by number of secondary branches per plant, these are confirmation with earlier findings of Shoba (2009), Vishnuvardhan *et al.* (2012), Wadikar *et al.* (2018).

Table 1: Estimates of genetic parameters for 16 characters in Valencia groundnut

Characters	Range	Mean	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation (GCV) (%)	Phenotypic coefficient of variation (PCV) (%)	Heritability in b.s. (%)	Genetic advance	Genetic advance expressed as per cent of mean (%)
Days to 50% flowering	28.33 - 39.00	34.486	9.912	11.012	9.129	9.62	89.97	6.152	17.839
Days to maturity	96.33 - 108.00	102.90	10.00	11.11	3.074	3.24	90.10	6.183	6.009
Plant height (cm)	21.40 - 30.13	26.536	5.056	6.207	8.474	9.39	81.46	4.181	15.756
No. of primary branches / plant	2.13 - 3.13	2.6056	0.059	0.074	9.38	10.44	80.66	0.452	17.354
No. of secondary branches/ plant	4.13 - 5.60	4.8833	0.251	0.271	10.264	10.66	92.70	0.994	20.352
Number of pods per plant	8.47 - 18.27	12.075	7.444	8.141	22.595	23.63	91.40	5.375	44.511
Biomass per plant (g)	18.27 - 26.87	21.961	7.010	8.102	12.056	12.96	86.52	5.073	23.102
Hundred pod weight (g)	87.67 - 139.33	116.65	228.98	237.76	12.972	13.22	96.30	30.591	26.224
Hundred kernel weight (g)	31.67 - 73.33	48.778	140.08	148.12	24.264	24.95	94.60	23.71	48.609

Characters	Range	Mean	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation (GCV) (%)	Phenotypic coefficient of variation (PCV) (%)	Heritability in b.s. (%)	Genetic advance	Genetic advance expressed as per cent of mean (%)
Shelling out-turn (%)	58.16 - 74.66	68.796	17.32	17.97	6.05	6.16	96.40	8.419	12.237
Pod yield per plant (g)	6.13 - 15.43	8.7583	6.487	6.692	29.081	29.54	96.90	5.166	58.983
Kernel yield per plant (g)	4.07 - 11.43	6.0722	4.077	4.179	33.253	33.67	97.60	4.108	67.659
Oil content (%)	42.67- 48.33	45.333	2.560	2.908	3.53	3.76	88.04	3.093	6.822
Reproductive efficiency (EF_1)	36.55 - 55.82	47.496	34.34	40.82	12.34	13.45	84.13	11.072	23.312
Reproductive efficiency (EF_2)	47.06 - 66.87	57.786	36.30	38.79	10.43	10.78	93.60	12.006	20.776
Harvest index (H)	24.08 - 66.64	39.985	94.54	100.32	24.32	25.05	94.20	19.445	48.63

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Quantifying Response of Pre Released Kharif Grain Sorghum Genotype to Different Fertility Levels Under Dry Land Condition

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Abstract: Field experiment was conducted on *kharif* grain sorghum at Sorghum Research Unit, Dr. PDKV, Akola, MS during *2018* and 2019 under rainfed condition to find out the performance of promising *Kharif* sorghum hybrids to fertilizers interaction. The experiment was laid out in factorial randomized block design with three replications. Test entries SPH-1846, SPH-1849 (2018) and SPH-1883, SPH-1886 (2019) were tested with the respective checks viz, CSH-16, CSH-25 and CSH-30) for their response to the three different fertilizer levels (F_1 - 75 % RDF, F_2 - 100 % RDF and F_3 - 125 % RDF). During 2018-2019, test genotype SPH-1846 (2018) and SPH-1886 (2019) recorded the highest values for highest plant height (cm), grain weight per panicle (g), grain number per panicle , weight of cob and length of panicle (cm). With the fertility level, growth and yield contributing character were found significantly maximum with application of fertilizer with $\mathbf{F_3}$. 125 % RDF.

Among the different four tests and three check genotypes, hybrid SPH-1846 (2018) and SPH-1886 (2019) were recorded the significantly highest grain yield ,fodder yield and biological yield. Among the three different fertility levels, application of 125 % RDF ($\mathbf{F_3}$), recorded the significantly highest grain yield , fodder yield and biological yield over the fertilizer levels - 75 % RDF ($\mathbf{F_1}$). The fertilizer application with $\mathbf{F_2}$: 100 % RDF recorded the second highest grain, fodder and biomass yield, which was found on par with application of 125 % RDF ($\mathbf{F_3}$). Interaction effect found significant for grain, fodder and biomass yield. Significantly highest monetary advantage and B:C ratio was found with the test genotype SPH-1846, SPH-1886 and fertility level 125 % RDF.

Keywords: Sorghum, Fertility level and Genotype.

Introduction

Sorghum (*Sorghum bicolor* L.), is one of the most important cereal crops in India. It is the fourth most important cereal crop of the world. It occupies a major niche in the many semi-arid subtropical farming systems due to its low cost of production and better response to favorable conditions with high yield. In addition, it is a double purpose crop; as a fodder and grains. The low productivity of sorghum is primarily because it is often grown on marginal lands with low N, P, K by resource poor farmers. The availability of high yielding and fertilizer responsive cultivars of sorghum has injected new enthusiasm in fertilizer research. Therefore, it is important to assess the magnitude of their response to fertility levels and simultaneously find out the production potential. This encouraged us to investigate the response of promising sorghum cultivars to split application of nitrogen. Nutrient uptake of sorghum was higher at optimum N,P, K in the root zone depth which enhances the better crop yield and its components and chemical contents. Similar results were reported by Mokashi *et al.* (2008) and Akdeniz *et al.*, (2000).

Low productivity of sorghum is one of the major constraints. Reasons for which are identified as lack of improved high yielding cultivars, delayed sowing, low fertilizer use and improper adoption of management techniques. Nitrogen is the essential element required for plant growth in relatively large amounts. However, deficiencies of nitrogen are common. Nitrogen deficiency can result in reduced dry matter, crude protein and grain yield (Jarvis, 1996; Ashiono *et al.*, 2005). Soil nutrients become depleted due to leaching of nitrogen, soil erosion and removal by crops (Zobeck *et al.*, 2000). In India, the area under sorghum is approximately 5.30 million hectares with an annual production of about 5.05 million tonnes and an average productivity of 953 kg ha-1 (Anonymous, 2016).Sorghum is mainly grown in Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan. The production can be increased by adopting improved package including suitable genotype, optimum plant geometry and appropriate fertilization. Hence, there is dire need to identify high yielding cultivars suitable for the region with optimum fertilizer dose. Sorghum cultivars are known to vary in their response to fertilizers. Productivity of sorghum is limited by soil fertility. Kumar *et al.*, (2010) reported that the increase in productivity of sorghum could be brought out both by genetic improvement as well as associated nutrient management intervention in a rainfed environment.Optimum dose of nitrogen, phosphorous and potassium is dependent on several factors like soils, crop, environment and crop growing situations, further genotype plays an important role in increasing crop production but information on the response of newly evolved genotypes/ varieties to nitrogen, phosphorous and potassium levels is meager. The development of elite genotype is a continuous process and currently many genotypes of different maturity groups have been evolved. Hence, there is a need to explore and evaluate the interaction of sorghum cultivars and fertilizers application in rainfed sorghum. The present study was planned to quantify the response of sorghum cultivars to fertilizer levels and so as to develop best management practices under rainfed conditions to achieve higher yields with low cost of production.

Materials and Methods

The field experiments was carried out at the Sorghum Research Unit Farm, Dr. PDKV, Akola of Maharashtra during 2018 and 2019. The experimental site is between latitudes 23° 43' N and 77 ° 64' E longitudes with an altitude of 281 m above mean sea level. The experiments were carried out during two successive kharif seasons of 2018 and 2019. The response of sorghum cultivars Viz, SPH-1846, SPH-1849, CSH-16, CSH-25 and CSH-30 (2018) and also genotype SPH-1883, SPH-1886, CSH-25 and CSH-30 (2019) were studied with the three different fertilizer levels (*F_1:75 % RDF, F_2:100 % RDF and F_3:125 % RDF*) under rainfed conditions. Among the cultivars SPH-1846, SPH-1849, SPH-1883, SPH-1886 is the test hybrids and CSH-16, CSH-25 and CSH-30 are the check inbred lines. The different genotype and three different fertilizer levels were laid out in a factorial randomised block design with three replications. Soil samples collected before cultivation and analyzed for physical and chemical properties analysis whereas, soil pH of experimental site was found to be vary from 8.27 to 8.31, available nitrogen 181 to 189 Kg ha^{-1}, available phosphorus 20.00 to 22.30 Kg ha^{-1} and available potassium 317 to 331 Kg ha^{-1} were observed in the first and second seasons respectively. The seasonal mean temperature ranged between 28.0° C to 36.0 ° C (Max) and 18.1° and 24.6° (Min) during both the year. Total rainfall received during 2018 and 2019 were 839.5 and 930.2 mm distributed over 40 and 56 rainy days, respectively.

Seeds of sorghum cultivars used for sowing which was obtained from Indian Institute of Millets Research, Hyderabad. Normal cultural practices for sorghum were applied as recommended till harvest. The recommended dose of fertilizer was 80-40-40 N-P_2O_5-K_2O kg ha^{-1}. The fertilizer sources used were through urea for N (46 % N), single super phosphate for P (16 % water soluble P_2O_5) and muriate of potash for K (60 %). As per the treatments, entire dose of P and K and half of the N were applied at the time of sowing as a basal dose, remaining dose of N was applied at 30 DAS as top dressing. Seed rate was 10 kg ha^{-1} and sown manually on 30.06.2018 and 01.07.2019 with a spacing of 45 cm between rows and 15 cm between plants. The plot area was 15.84 m^2 (3.60 m length × 4.40 m width). Plants were thinned to a single plant per hill maintaining distance between the plant 15 cm apart. The growth and yield parameters as well as yield at harvest were recorded as per standard procedures. The amount of inputs and outputs per hectare were multiplied with a wage or price of the unit to consolidate all of them in one unit (Rs ha^{-1}) to find out the economic indices *viz*., total cost of production, gross returns, net returns and benefit cost ratio. The data were analysed statistically by using analysis of variance according for a factorial randomised block design (Two factors) (Gomez and Gomez 1984) and the differences of means were identified by critical difference (CD) at $P \geq 0.05$.

Results and Discussion

Effect of cultivars on growths and yields contributing components of *Sorghum bicolor*

Data pertaining to the growth and yield parameters is presented in table 01. The analysis of data and results showed that, plant height (cm), days to 50 % flowering, 100 seed weight (g), grain weight per panicle (g), grain no. per panicle and length of panicle (cm) found significant due to the performance of Test and Check Sorghum hybrid during 2018-19 and 2019-20.

During 2018-19, among the different two test and three check genotype, significantly highest plant height (cm), grain weight per panicle (g), grain no. per panicle and length of panicle (cm) were recorded with the test hybrid SPH-1846 and it was found at par with the test hybrid SPH-1849 and check hybrid CSH-25 for plant height and grain weight per panicle. However, days to 50 % flowering and 100 seed weight differ significantly due to the Check hybrid CSH-30 and found at par with test hybrid SPH-1849. Days to 50 % flowering were significantly varied with test and check hybrid genotypes, among all the check CSH-30 recorded lowest days to 50 % flowering and in test hybrid SPH-1849 recorded minimum days to 50 % flowering. Whereas weight of cob (g) recorded highest with SPH-1846, but did not differ significantly with the performance of test and check genotype. Among all the genotype, test hybrid SPH-1846 recorded significantly superior values for Length of panicle (cm) over all other genotype.

Table 01: Main effect of genotype on yield components of *Sorghum bicolor* in the two growing seasons

Genotypes	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
2018-19							
SPH-1846	178.96	71.56	2.08	40.02	82.11	1918	29.73
SPH-1849	173.83	70.44	2.35	38.57	76.96	1646	24.81
CSH-16	171.67	71.56	2.23	37.97	59.29	1712	26.18

Genotypes	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
CSH-25	176.83	74.67	2.23	39.04	68.82	1757	26.84
CSH-30	167.67	69.00	2.38	33.00	61.09	1393	22.98
SE (m) ±	2.48	0.53	0.05	1.04	8.38	52	0.67
CD at 5 %	7.18	1.55	0.15	3.00	NS	150	1.94
	2019-20						
SPH-1883	166.30	66.28	2.49	29.02	80.13	1160	25.89
SPH-1886	191.10	69.22	2.81	**33.52**	81.90	1191	25.90
CSH-25	189.00	73.00	2.90	22.34	61.33	771	19.22
CSH-30	179.15	66.27	2.59	30.58	67.80	1173	21.31
SE (m) ±	3.27	1.07	0.05	1.00	7.49	35	0.78
CD at 5 %	9.54	3.11	0.14	2.91	NS	102	2.28

During 2019-20, among the different two tests and two check genotypes, significantly highest plant height (cm), grain weight per panicle (g) and grain no. per panicle were found significantly highest with the test hybrid SPH-1886. Plant height values were found at par with the check hybrid CSH-25, in case of grain no. per panicle was found at par with check hybrid CSH-30 and test hybrid SPH- 1883 but, grain weight per panicle; it was found significantly superior over all other genotypes. However, Days to 50 % flowering differ significantly due to the check hybrid CSH-30 and test hybrid SPH – 1883 and recorded minimum days to 50 % flowering. The 100 seed weight was found significantly highest with check genotype CSH-25 and it was found at par with test genotype SPH- 1886. Whereas, length of panicle and harvest index recorded significantly highest with SPH-1883 and it was found at par with SPH- 1886. Among all the genotype, test hybrid SPH-1886 recorded significantly superior values for grain weight per panicle over all other genotype.

In general, genotype SPH- 1846 (2018-19) and SPH-1886 (2019-20) were recorded maximum plant height of 178.96 cm and 191.10 cm, respectively compared to other test and check genotype. The variation in plant height in sorghum varieties at different levels of fertilizer application was also earlier reported by George Yakubu Mahama (2012). Among the all genotype, variation was obtained with plant height, grain weight per Panicle (g), grain no. per Panicle and Length of Panicle (cm).

Effect of different Fertility Levels on growths and yields contributing components of *Sorghum bicolor*

During the succeeding two growing seasons (Table 2), the yield of sorghum and its attributes; exhibited significant differences for different fertility levels. During 2018-19, Plant Height (cm), 100 Seed Weight (g), Grain Weight per Panicle (g), Grain No. per Panicle and Harvest Index (%) were found significantly maximum with F_3 fertility levels (125 % RDF). However, it was found at par with the application of 100 % recommended dose of fertilizer (F_2). Among all the fertility levels, F_3 fertility levels recorded significantly superior values for grain weight per panicle. The significantly minimum days to 50 % flowering was recorded with F_3 and found at par with F_2. However, length of panicle was found highest with F_3 level but did not differ significantly due to the different fertility levels.

Table 02: Main effect of fertility levels on yield components of *Sorghum bicolor* in the two growing seasons

Fertility levels	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
				2018-19			
F1 -75 % RDF	168.64	72.20	2.22	33.20	57.39	1510	24.87
F2 -100 % RDF	173.00	71.33	2.22	38.92	73.25	1762	26.37
F3 -125 % RDF	179.73	70.80	2.32	41.05	78.32	1783	27.09
SE (m) ±	1.92	0.41	0.04	0.80	6.49	40	0.52
CD at 5 %	5.56	1.20	NS	2.32	NS	117	1.51
				2019-20			
F1 -75 % RDF	174	70.19	2.60	24.51	54.10	944	22.43
F2 -100 % RDF	184	68.86	2.69	29.68	58.11	1110	22.80
F3 -125 % RDF	186	67.03	2.80	**32.40**	59.22	1168	23.55
SE (m) ±	2.83	0.92	0.04	0.86	5.22	30	0.68
CD at 5 %	8.27	2.69	0.12	2.52	NS	89	NS

During 2019-20, plant height (cm), Grain Weight per Panicle (g), Grain No. per Panicle and Length of Panicle (cm) were found significantly maximum with F_3 fertility levels (125 % RDF). However in case of Grain Weight per Panicle (g), Grain No. per Panicle and Length of Panicle, Fertility level F_3 were found at par with the application of 100 % recommended dose of fertilizer (F_2). Whereas, 100 seed weight and Wet of Cob (g) were not affected significantly due to the different fertility levels. Interaction had significant effect on all the growth parameter except 100 Seed Weight (g) and Weight of Cob (g). Similarly there was increase in all growth parameters were observed with increase in levels of fertilizer application, found maximum with 125 % and lowest with 75 % recommended dose of fertilizer levels. This could be attributed to soil enrichment with higher level of nutrients which owing to provide sufficient nutrients that are essentially required to various metabolic processes and finally resulting in plant growth. Better nutritional balance in soil solution favored better growth and yield contributing characters. The result of present findings was tally with the findings of Thakre *et al.* (1989) and Mahakulkar *et al.* (1992).

Effect of cultivars on yields and economics of *Sorghum bicolor*

The Grain yield, Fodder yield and Biomass yield obtained with different genotype during 2018 and 2019 is presented in Table No. 03. The mean yield values obtained in this experiment was ranged in between 32.72 to 50.28 q ha^{-1} for grain, 107.0 to 131.0 q ha^{-1} for fodder and 149 to 181 q ha^{-1} for biomass.

The Grain yield, Fodder yield and Biomass yield obtained with different genotype during 2018-149 is presented in Table No. 03. The results of 2018-19 showed that , among the different two test and three check genotype , test hybrid SPH-1846 recorded the significantly highest grain yield (36.94 q ha^{-1}), fodder yield (123.00 q ha^{-1}) and biological yield (160.00 q ha^{-1}). However, in case of grain yield test hybrid SPH-1846 found at par test hybrid SPH-1849 and check hybrid CSH-25 and CSH-16. The test genotypes SPH-1849 and CSH-30 was found at par with SPH-1846 for fodder and biomass yield. During 2019-20, lowest grain yield recorded with check genotype CSH-30 and lowest fodder and biomass yield were recorded with check genotype CSH-16. The results showed that , among the different two test and two check genotype , test hybrid SPH-1886, recorded the significantly superior grain yield (50.28 q ha^{-1}), fodder yield (131.00 q ha^{-1}) and biological yield (181.00 q ha^{-1}), However, in case of fodder yield test hybrid SPH-1886 found at par check hybrid CSH-25. The lowest grain yield recorded with check genotype CSH-25, lowest fodder and biomass yield were recorded with test genotype SPH- 1883.

Table 03: Main effect of cultivars on yield and economics of *Sorghum bicolor* in the two growing seasons

Genotypes	Grain Yield q ha^{-1}	Fodder Yield q ha^{-1}	Biomass Yield q ha^{-1}	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	Benefit Cost Ratio
2018-19						
SPH-1846	36.94	123	160	91100	67630	2.88
SPH-1849	35.36	119	154	87363	63893	2.72
CSH-16	34.22	95	129	80540	57070	2.43
CSH-25	35.20	103	138	83962	60492	2.57
CSH-30	29.08	110	139	74273	50803	2.15
SE (m) ±	1.37	5.98	5.99	2614	2614	
CD at 5 %	3.96	17.32	17.34	7573	7573	
2019-20						
SPH-1883	42.70	107	149	96072	70352	3.71
SPH-1886	50.28	131	181	113620	87900	4.40
CSH-25	32.72	125	157	77905	52185	3.04
CSH-30	45.18	117	163	102106	76386	3.96
SE (m) ±	1.41	3.5	3.7	2837	2837	
CD at 5 %	4.11	10.1	10.9	8282	8282	

Economics worked out from the emerged data is presented in table No. 03. The economics analysis of study of 2018-19 revealed that, significantly highest monetary advantage in terms of gross monetary returns was found with the test genotype SPH-1846 and closely followed by test genotype SPH-1849 and check genotype CSH-25. Similarly, test hybrid SPH-1846 and 1849 recorded highest B:C Ratio but in fertility levels. Economics worked out from the emerged data of 2019-20 is presented in table no. 03. The economics analysis of study revealed that, significantly highest monetary advantage in terms of gross monetary returns was found with the test genotype SPH-1886 and followed by check genotype CSH-30.

Effect of fertility levels on yields and economics of *Sorghum bicolor*

The results of first year data showed that, among three different fertility levels, application of 125 % RDF (**F_3**), recorded the significantly highest grain yield (37.07 q ha^{-1}), fodder yield (117.00 q ha^{-1}) and biological yield (154.00 q ha^{-1}) over the fertilizer levels - 75 % RDF (**F_1**). The fertilizer application with **F_2**: 100 % RDF recorded the second highest grain, fodder and biomass yield, which was on par with application of 125 % RDF (**F_3**). The lowest grain, fodder and biomass yield recorded with application of 75 % RDF (**F_1**). Interaction effect found significant for grain, fodder and biomass yield.

During the 2019-20, among the three different fertility levels, application of 125 % RDF (F_3), recorded the significantly highest grain yield (47.81 q ha^{-1}), fodder yield (126.00 q ha^{-1}) and biological yield (173.00 q ha^{-1}) over the fertilizer levels - 75 % RDF (F_1). The grain yield per ha found significantly superior with F_3 level. The fertilizer application with F_2: 100 % RDF recorded the second highest grain, fodder and biomass yield, which was on par with application of 125 % RDF (F_3) for fodder and biomass yield. The lowest grain, fodder and biomass yield recorded with application of 75 % RDF (F_1). This might be due to higher sink at higher level of nutrition manifested yield attributes to the maximum. Grain and fodder yield being a function of growth and yield contributing characters thus, the increased growth and yield attributing parameters might have directly contributed to higher grain and fodder yield. The results are corroborating with the work of Mahakulkar *et al.* (1992). Such improvements with increasing fertilizer levels were also reported by Chouhan and Dighe (1999), Wani et al. (2004), Buah and Mwinkaara (2009), Uchino *et al.* (2013) and Sami *et al.* (2014).

Table 04: Main effect of fertility levels on yield and economics of *Sorghum bicolor* in the two growing season

Fertility Levels	Grain Yield q ha^{-1}	Fodder Yield q ha^{-1}	Biomass Yield q ha^{-1}	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	Benefit Cost Ratio
2018-19						
F1 -75 % RDF	29.87	100	130	73711	51701	2.35
F2 -100 % RDF	35.55	112	148	86441	62971	2.68
F3 -125 % RDF	37.07	117	154	90190	65260	2.62
SE (m) ±	1.06	4.6	4.64	2025	2025	0.09
CD at 5 %	3.06	13.4	13.43	5866	5866	0.25
2019-20						
F1 -75 % RDF	36.34	113	149	83978	59468	3.43
F2 -100 % RDF	44.02	121	165	100118	74398	3.89
F3 -125 % RDF	47.81	126	173	108182	81252	4.02
SE (m) ±	1.22	3.01	3.24	2457	2457	
CD at 5 %	3.56	8.78	9.47	7173	7173	

Economics worked out from the emerged data is presented in table No. 04. The economics analysis study for the 2018-19 revealed that, significantly highest monetary advantage in terms of gross monetary returns was found with application 125 % RDF and closely followed by application 100 % RDF. Also Net Monetary Returns found significantly highest with the F_3, which was recorded at par values with F_2. Application of 100 % RDF fertility levels recorded highest B:C Ratio. During 2019-20, among three different fertility levels, highest GMR were recorded with application 125 %.

Table 05: Interaction effect of cultivars and fertility levels on yield components of sorghum during 2018-19 and 2019-20 seasons.

Genotypes * Fertilizer	Plant Height (cm)	Days to 50 % Flow.	100 Seed Wt. (g)	Grain Wt. per Panicle (g)	Wt. of Cob (g)	Grain No. per Panicle	Length of Panicle (cm)
Interaction Genotypes x Fertilizer							
2018-19							
CD at 5 %	12.43	2.68	NS	5.20	NS	261	3.37
2019-20							
CD at 5 %	NS	NS	NS	12.88	NS	210	NS

RDF and subsequently followed by application 100 % RDF. The fertility level F_3 - recorded the highest value of NMR, which was at par with F_2 and also fertility level F_3 recorded the highest B:C Ratio. The results were confirmed with the findings of Mishra et al. (2009).

Table 06: Interaction effect of cultivars and fertility levels on yield and economics sorghum during 2018-19 and 2019-20 seasons.

Genotypes * Fertilizer	Grain Yield q ha^{-1}	Fodder Yield q ha^{-1}	Biomass Yield q ha^{-1}	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})
Interaction Genotypes x Fertilizer					
2018-19					
CD at 5 %	6.85	30.00	30.04	13117	13117
2019-20					
CD at 5 %	7.52	22.00	24.55	14789	17489

Interactions between cultivars and fertilizer levels

The interaction effect between cultivars and different fertility levels (Table 05 and 06), data shown significant effect on plant height (cm), days to 50 % flowering, grain weight per panicle (g), grain number per panicle, length of panicle (cm), grain yield (kg ha^{-1}), fodder yield (kg ha^{-1}), biomass yield (kg ha^{-1}), GMR and NMR (Rs ha^{-1}) during 2018-19. The data obtained from second season showed that, grain weight per panicle (g), grain number per panicle, grain yield (kg ha^{-1}), fodder yield (kg ha^{-1}) biomass yield (kg ha^{-1}), GMR(Rs ha^{-1}) and NMR (Rs ha^{-1}) recorded significant impact. The obtained data showed that increasing fertility level from 75 % to 125 % RDF and genotype SPH-1846 (2018-19) and SPH – 1886 (2019-20) together led to an encouragement in grain formation owing to increasing the plant capacity in building metabolites and caused increase in grain and head weight. Application of 125 % RDF under rainfed sowing genotype SPH-1846 (2018-19) and SPH – 1886 (2019-20) gave maximum grain yield, Fodder yield, biological yield, GMR, NMR and B:C ratio.

Conclusion

It could be concluded from the experimental data that sowing of sorghum crop (Sorghum bicolor L.) genotype SPH-1846 (2018-19), SPH – 1886 (2019-20) and fertilized by 125 % Recommended Dose of Fertilizers were observed in order to raise a healthy and good sorghum crop and ultimately get the highest yield and monetary returns under dry land condition of Vidarbha . The application of 125 % RDF (F_3) recorded significantly higher grain yield and fodder yield as compared to rest of the fertilizer levels. Among the genotypes SPH-1846 (2018-19) and SPH – 1886 (2019-20) produced more grain, fodder yield, GMR and NMR as compare to other genotypes only they were at par with each other.

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Theme III

Research and Innovation in Agricultural Technology

Biogas Production from Cattle Dung and Cattle Dung Inoculated With Shredded Cotton Stalks

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Abstract: Evaluate the performance of 2 m^3 modified Janta biogas plant using cattle dung and cattle dung inoculated with shredded cotton stalks. The average particle size of cotton stalk was found to be 1.78 mm. The proximate analysis of cotton stalk determined the average moisture content, volatile matter, ash content and fixed carbon and it was found to be 7.20, 68.80, 5.40 and 18.60 %, respectively. The total cumulative biogas production from cattle dung in the month of August-2018, December-2018, February-2019 and April-2019 was 141114 liter whereas the total cumulative biogas production from cattle dung inoculated with shredded cotton stalks in the month of September-2018, January-2019, March-2019 and May-2019 was 158809 liter. The total cumulative biogas production from both feed stocks was found to be 299923 liter. The total average methane content of biogas from cattle dung in the month of August-2018, December-2018, February-2019 and April-2019 was 56.92 % whereas the total average methane content of biogas production from cattle dung inoculated with shredded cotton stalks in the month of August-2018, December-2018, February-2019 and April-2019 was 59.59 %. The total average methane content from both feed stocks was found to be 58.25 %. Overall results indicated that the cattle dung (75 %) and cotton stalk (25 %) substrate mixed in equal proportion of water ratios as 1:1 gave sufficient biogas production and observed higher methane content in the month of May-2019. The biogas production may vary with respect to change in temperature and revealed that increased slurry temperature affects biogas production positively.

Keywords: Anaerobic digestion, Cotton stalk, Cattle dung, Biogas production, Composition of biogas, Biogas analyzer, Biogas flow meter.

1. Introduction

India has an estimated renewable energy potential of about 900 GW from commercially exploitable sources viz. wind 102 GW (at 80 meter mast height), small hydro 20 GW, bioenergy 25 GW and 750 GW solar powers, assuming 3% wasteland is made available. Renewable energy has a great potential to usher in universal energy access. In a decentralized or standalone mode, renewable energy is an appropriate, scalable and viable solution for providing power to un-electrified or power deficient villages and hamlets (Tomar and Singh, 2018).

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste (Pruthviraj, 2016).

Biogas is a clean renewable energy produced from organic wastes using anaerobic digestion as a process. Anaerobic digestion is the biological degradation of biomass in oxygen-free conditions. In the absence of oxygen, anaerobic bacteria will ferment biodegradable matter into methane (40-70 %), carbon dioxide (30-60 %), hydrogen (0-1 %) and hydrogen sulfide (0-3 %), a mixture called biogas. Biogas is formed solely through the activity of bacteria. Although the process itself generates heat, additional heat is required to maintain the ideal process temperature of at least 35°C.

Every year in the world several million tons of agricultural wastes are being disposed through different ways such as incineration, land applications and land filling. This global waste has a high potential as a bio renewable energy resource and can be turned into high-value by-products. Cotton waste (cotton plant stalks, leaves, cottonseed hulls) is one of the agricultural wastes that is considered as ''energy source'', especially in countries in which the cotton is being planted on a large scale such as China, Brazil, India, Pakistan, Turkey and Australia (Isci and Demirer, 2016).

In India total area, production and productivity of cotton under cultivation is 10826 thousand hectare, 32577 thousand bales of 170 kg each and 512 kg/ha respectively (Indiastat 2016-2017) while total area, production and productivity of cotton under cultivation in Maharashtra is 42.07 lakh hectare, 85 lakh bales of 170 kg and 348.48 kg/ha respectively (Indiastat 2017-2018).

It is estimated that about 23 million tons of cotton stalk is generated in India every year. Most of the stalk produced is treated as waste though a part of it is used as fuel by rural masses (Gurjar et al., 2007).

2. Materials and Methods

2.1 Location and site

Akola is located at latitude 20.7° north and longitude 77.07° east. It is at an altitude of 287 m to 316 m above sea level. The 2 cubic meter modified Janta biogas plant used for present research work was available at Department of Agronomy at Post Graduate Institute, Dr. PDKV, Akola.

2.2 Source of cattle dung and cotton stalk for biogas production

The fresh cattle dung for feeding purpose was available at cattle shed of Department of Agronomy, Dr. PDKV, Akola and agricultural crop residues of cotton was collected from the field of cotton research centre, Dr. PDKV, Akola.

2.3 Sizereductionofcotton stalk

The required size of particles was prepared to fulfill the requirements of biogas production and to achieve high biogas yield. Feed stock material specifications range was less than 2 mm for biogas production (Bridgwater and Peacocke, 2000). The size reduction of agricultural crop residues was made by shredder machine and sieve shaker are given in Fig. 1 and 2.

Fig. 1 Biomass shredder used for shredding of cotton stalk

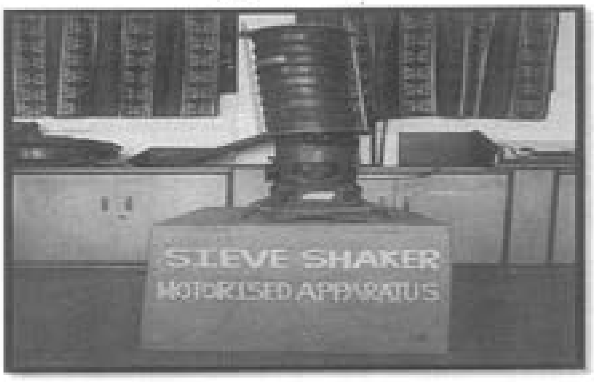


Fig.2 Sieve Shaker used for sieve analysis of cotton stalk

2.3 Characterization of cotton stalk

In order to assess the quality of cotton stalk, it was characterized for its sieve analysis and proximate analysis.

2.3.1 Sieve analysis of cotton stalk

A sieve analysis is a practice or procedure used to assess the particle size distribution of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that was stopped by each sieve as a fraction of the whole mass.

Average particle size of the cotton stalk was taken on the basis of fineness modulus.

1. **Fineness modulus (FM)**

$$FM = \frac{\sum \text{Cumulative percentage retained on specified sieves)}}{100}$$

2. **Average particle size (D_{avg})**

$$D_{avg} = \frac{b}{\sqrt{a}} \times a^{FM}$$

Where, a = Constant (i.e. a = 2 for India)

b = Smallest sieve size in mm

2.3.2 Proximate analysis

In a proximate analysis of cotton stalk, it was characterized for determination of moisture content, volatile matter, ash content and fixed carbon and procedure followed for its determination as discuss below.

1. Moisture content : Finely powered air dried cotton stalk sample was weighed in a crucible. The crucible was placed inside an electric hot air-oven and maintaining temperature at 105 to 110°C (ASTM D 3173). The crucible was allowed to remain in oven for one hour and then it was taken out, cooled in desiccator and was weighted and loss in weight was the moisture content on percent basis.

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where, W_1 = Weight of crucible, g

W_2 = Weight of crucible + sample, g

W_3 = Weight of crucible + sample, after drying, g

2. Volatile matter content : The dried sample of biomass left in crucible was then covered with a lid and was placed in an electric muffle furnace, maintaining temperature at 925 ± 20°C (ASTM D 3174). The crucible was taken out from oven after seven minute of heating. The crucible was cooled first in air, then was cooled inside desiccator and was weighted again. Loss in weight was the volatile matter on percent basis.

$$\text{Volatile matter (\%)} = \frac{A-B}{B} \times 100$$

Where, A = Weight of the oven dried sample (g)

B = Weight of the sample after 7 min in the furnace at 925°C

3. Ash Content : The residual biomass in the crucible then was heated without lid in a muffle furnace at temperature 700 ± 50°C for half an hour. The crucible then was taken out, was cooled first in air, then in desiccator and was weighed. Heating, cooling and weighing was repeated, till a constant weight obtained. The residue was ash on percentage basis.

$$\text{Ash content (\%)} = \frac{C}{A} \times 100$$

Where, A= Weightofsample, (g)

C = Weight ofsample after combustion, (g)

4. **Fixed carbon :** Fixed carbon was calculated using following equation

Fixed Carbon = 100 - [% of MC + VM + FC]

2.4 List of instruments used in experiment

1. Thermo-hygrometer : Thermo-hygrometer was used to measure the ambient temperature and relative humidity during the digestion period.

2. Digital temperature indicator : Digital temperature indicator was used to measure the digester temperature during the digestion period.

3. Biogas flow meter : Gas flow meter was used to measure the flow rate of biogas in liter.

4. Biogas analyzer: Biogas analyzer instrument was used to measure the composition of produced biogas. It gives the composition of methane (%), carbon dioxide (%) and hydrogen sulfide (ppm) present in the biogas.

2.5 Selection of feed stock ratio to evaluate the performance of 2 cubic meter modified Janta biogas plant

For present study the feed stock ratio used to evaluate the performance of 2 cubic meter modified Janta biogas plant using cattle dung was 50 kg cattle dung and 50 liter water ratios as (1:1). The same feed stock ratio was used by Kamble (2016). He studied the performance of 2 cubic meter modified Janta biogas plant. The plant was fed every day with a mixture of 50 kg of cattle dung and 50 liter of water for a period of about two months.

Similarly the feed stock ratio used to evaluate the performance of 2 cubic meter modified Janta biogas plant using cattle dung inoculated with shredded cotton stalks was 75 % (cattle dung), 25 % (cotton stalk) and 100% (water) in ratio (1:1). The same feed stock ratio was used by Kirjat (2017). He studied biogas production from soybean and cotton stalks substrate. In his study he observed that the optimum gas production was obtained in the proportion of 25 (soybean stalk and cotton stalk): 75 (Cattle dung) in the substrate of soybean and cotton i.e. 40,320 ml from 1500 ml TMS and 32,445 ml from 1500 ml TMS respectively. Thus the highest biogas production, suggesting the proportion of 25:75 substrates is an optimal mix to yield better amount of biogas.

2.6 Biogas plant details

The 2 cubic meter modified Janta biogas plant used for present study was installed at Department of Agronomy, Dr. PDKV, Akola (Fig 3 and 4). This biogas plant has feeding capacity of 50 kg feed stock and 50 liter water ratio (1:1). In this plant we feeded two feedstock's i.e. cattle dung and water in proportion (1:1) and cattle dung (75 %), cotton stalk (25 %) and water in proportion (1:1). The above mentioned mixtures of two feed stocks were feeded alternatively one after the other month and biogas production was evaluated.

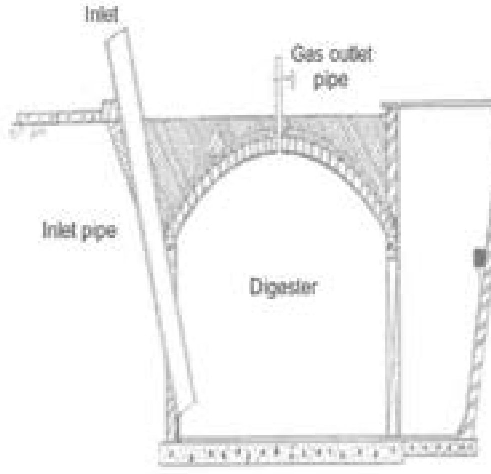
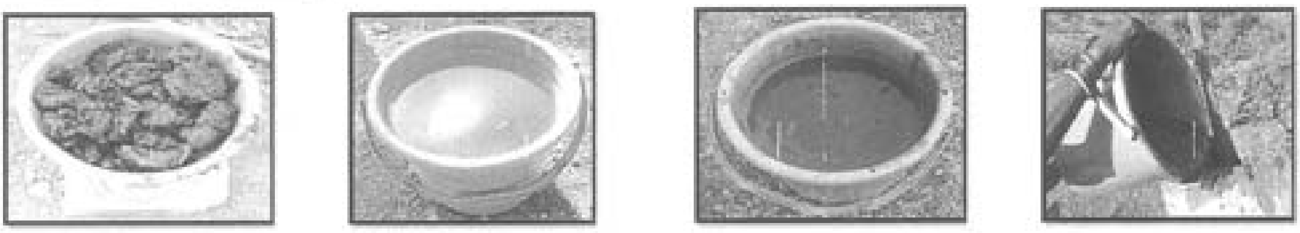


Fig.3. Schematic view of modified Janta biogas plant

Fig.4. Two cubic meter modified Janta biogas plant

2.6.1 Performance of biogas plant using cattle dung as feed stock

The 2 cubic meter Janta biogas plant used for present study. This biogas plant has feeding capacity of 50 kg cattle dung and 50 liter water. Fresh cow dung was collected from the cattle shed of Department of Agronomy. The cow dung was mixed with tap water at the ratio 1:1 and then obtained mixture was feeded in inlet chamber of 2 cubic meter modified Janta biogas plant. After mixture was feeded, daily observations of biogas production, composition (CH_4, CO_2, H_2S) of biogas, digester temperature, ambient temperature and relative humidity on hourly basis from 9 am to 6 pm were recorded. The experimental set up for experimentation is as shown in Fig. 5.

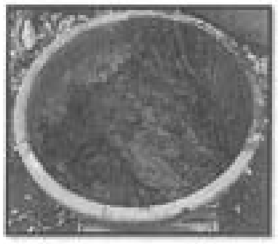


(a) Cattle dung **(b) Water** **(c) Mixture** **(d) feeding of mixture**

Fig. 5 (a) (b) (c) (d) Feeding of cattle dung

2.6.2 Performance of biogas plant using cattle dung inoculated with shredded cotton stalks

For production of biogas using cattle dung inoculated with shredded cotton stalks, agricultural waste cotton biomass was required as a feed stock but as such raw cotton biomass can't be use so physical treatment like cutting, drying and shredding was required. After that a mixture of cattle dung (75%), cotton stalk (25%)and water (100%) in ratio (1:1) was prepared. Then obtained mixture was feeded in inlet chamber of 2 cubic meter modified Janta biogas plant. After mixture was feeded, daily observations of biogas production, composition (CH_4, CO_2, H_2S) of biogas, digester temperature, ambient temperature and relative humidity on hourly basis from 9 am to 6 pm were recorded. The experimental set up for experimentation is as shown in Fig. 6


(a) Cattle dung


(b) Cotton Stalk


(c) Mixture


(d) feeding of mixture

Fig. 6 (a) (b) (c) (d) Feeding of cattle dung inoculated with shredded cotton stalks

3. Results and Discussion

3.1 Sieve analysis of cotton stalk

The average particle size of cotton stalk was found to be 1.78 mm.

3.2 Proximate analysis of cotton stalk

The results of proximate analysis are given in Table 1.

Table 1. Proximate analysis of cotton stalk

Sr. No.	Particulars	cotton stalk
1	Moisture content, (%)	7.20
2	Volatile matter, (%)	68.80
3	Ash content, (%)	5.40
4	Fixed carbon, (%)	18.60

3.3 Cumulative biogas production from cattle dung and cattle dung inoculated with shredded cotton stalks

The ambient temperature, digester temperature and cumulative biogas production, values from cattle dung and cattle dung inoculated with shredded cotton stalks for the month of August (2018), September (2018), December (2018), January (2019), February (2019), March (2019), April (2019) and May (2019) was given in Table 2.

Table 2.Cumulative biogas production from cattle dung and cattle dung inoculated with shredded cottonstalks

Sr. No.	Months	Ambient temp., (°C)		Digester temperature, (°C)	Production, (liter)
		Min	Max		
1	August, 2018	25.57	30.03	36.65	33644
2	September, 2018	25.47	31.37	37.81	38149
3	December, 2018	18.53	28.83	34.51	27884
4	January, 2019	18.63	29.50	37.05	31846
5	February, 2019	22.83	32.83	39.03	35031
6	March, 2019	28.93	37.43	43.02	41198
7	April, 2019	33.37	42.27	47.63	44555
8	May, 2019	34.93	43.50	48.53	47616
Average		26.03	34.47	40.53	37490
Total					299923

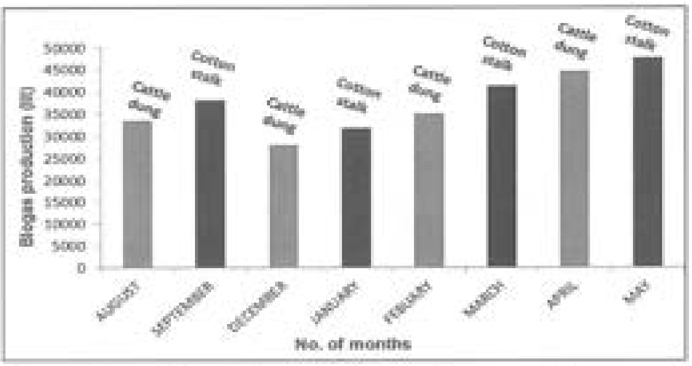


Fig. 7. Cumulative biogas production from cattle dung and cattle dung inoculated with shredded cotton stalks

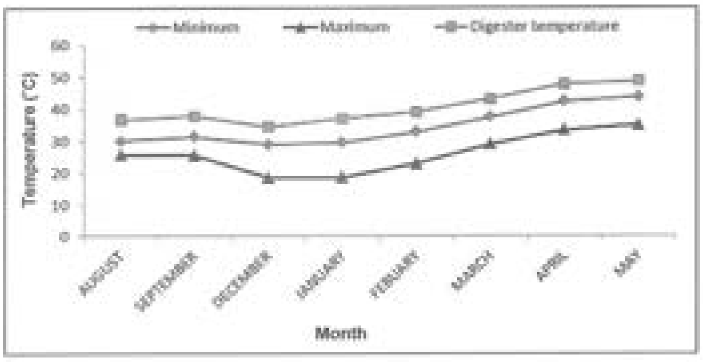


Fig. 8. Ambient temperature and digester temperature in the month of August-2018, September-2018, December-2018, January-2019, February-2019, March-2019, April-2019 and May-2019

3.4 Average composition of biogas from cattle dung and cattle dung inoculated with shredded cotton stalks

Average composition of biogas values from cattle dung and cattle dung inoculated with shredded cotton stalks for the month of August (2018), September (2018), December (2018), January (2019), February (2019), March (2019), April (2019) and May (2019) was given in Table 3.

Table 2. Average composition of biogas from cattle dung inoculated with shredded cotton stalks

Sr. No.	Months	CH_4,(%)	CO_2, (%)	H_2S, (%)
1	August, 2018	55.54	44.32	0.15
2	September, 2018	59.02	40.86	0.12
3	December, 2018	54.10	45.78	0.12
4	January, 2019	55.08	44.78	0.14
5	February, 2019	56.15	43.70	0.15
6	March, 2019	59.33	40.51	0.15
7	April, 2019	61.88	37.96	0.16
8	May, 2019	64.91	34.93	0.16
	Average	**58.25**	**41.61**	**0.14**

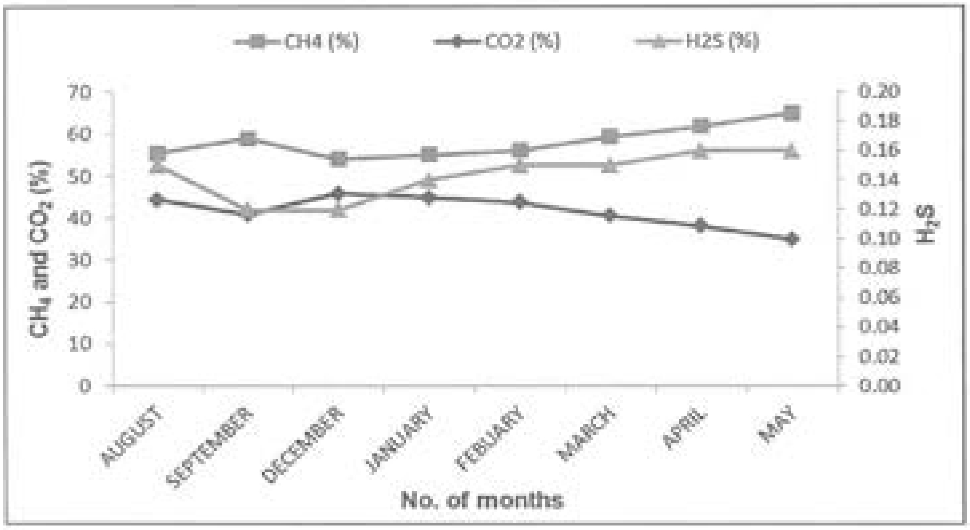


Fig. 9. Average composition of biogas from cattle dung and cattle dung inoculated with shredded cotton stalks

4. Conclusion

Based on the overall results indicated that the of cattle dung (75%) and cotton stalk (25%) substrate mixed with equal proportion of water ratios as 1:1 gave sufficient biogas production (1587.2 liter day-1) and observed higher methane content (64.91 %) in the month of May-2019. Hence cattle dung inoculated with shredded cotton stalks (75:25) may be used as an alternative feed stock in production of biogas in the region where cotton stalks are available. It can also be concluded that increase in temperature increased biogas yield and thus methane content in the biogas.

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Performance Evaluation of Women Friendly Ergonomically Suitable Harvesting Tool

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Abstract: Food is a necessity for every living thing, animals are no exception. Farmers having small piece of land, they also have rear animals to support their livelihood. Herbivorous animals rely on fodder for their food. Fodder usually grows in the field while cultivating crops. Cutting this fodder and removing it from the farms is a major activity in the farming process. This requires lots of efforts and it is a time-consuming process. There are various equipments available in the market for removing and cutting of fodder. There main feed is different types of grasses such as Lucerne, Elephant grass, Maize, jowar etc. There are many constraints like uneven height of cutting, higher cost of harvester for small-scale farmers, ergonomic shortcomings, etc. Due to these factors the feed harvesting is carried out by human labor in major parts of the country. The labour can develop Musculoskeletal Disorder (MSD's) due to incorrect posture, stress and continuous work. Ergonomics related to the design of methods and processes can help eliminate or decrease work related risks as well as improve the work quality and productivity. The developed women friendly harvesting tool performance evaluation conducted at Krishi Vigyan Kendra, Dediapada, Narmada Gujarat and nearby farmers field. It was used for harvesting Napier grass, Daincha green manuaring crop which works satisfactory.

Keywords: harvesting , Women friendly, Ergonomics, Anthropometry

There are variety of grass which serve the purpose of feeding animals. Every fodder grass has its importance in the diet of the livestock. Grass like Lucerne are a rich source in proteins while Maize, Elephant grass provide other nutrients. As per the Livestock inventory in India in 2019 India, the total number of cattle's are 192.49 million (Anonymous 2019). Thus, milk can be a good source of income to every farmer having certain number of cattle. There are many factors which affect milk productivity; fodder being a major factor. Fodder contributes in improving quality as well as quantity of milk. Therefore, the entire lifecycle of fodder grass/crop (sowing to harvesting) plays a vital role in obtaining good quality fodder.

In India, maximum farming operation is done on small and marginal holding size which poses a problem in using the mechanized equipments. However, manual harvesting techniques should also address the ergonomic aspect. Performing jobs in prolonged bending has resulted in numerous health effects such as chronic venous insufficiency, preterm birth and spontaneous abortion, and carotid atherosclerosis. (Fatellah *et. al*. 2008)

Lack of knowledge about ergonomics is observed in rural areas where work is carried out. The application of ergonomic principles would help to increase human performance and productivity, but mostly help human operator to be comfortable and secure. Ergonomics related to the design of methods and processes can help eliminate or decrease work related risks as well as improve the work quality and productivity. There is a need for implementation of gender friendly ergonomics intervention for harvesting (Thakur and Sharma,2000). The development of women friendly harvesting tool at College of Agricultural Engineering and Technology Dediapada.

Present Harvesting Method

Hazard identification is a way of switching between tasks to find out which ones have the potential to cause Musculoskeletal Disorder MSD. The Regulations implies to identify only those tasks that involve "hazardous manual handling". traditional practice, workers directly cut the crops with scythes and sickles (figure 1). They cut the crop while bending. The waist is bent at 90^0. This activity is continued for more than 8 hours. Cutting of crops requires force to be applied in this awkward posture.

- Repeated bending and cutting results in joint pain and back pain (problems in vertebrae) in due course of time.
- The monotonous activity also results in mental fatigue and stress, which affects the working efficiency.

Repetitive or Sustained Movement

Repetitive or sustained movement means using the same parts of the body to repeat similar movements over a period.

Fig 1: Workers cutting the grass with scythe

Repetitive or sustained movement includes (as shown in figure 1):

- Cutting the grass with scythe for prolong duration.
- Sustained movement while bending the back.

Development Ergonomically Suitable Women Friendly Harvesting Tool

India's economic and social strategy are Atmanirbhar Bharat Abhiyaan (self-reliant India movement) (ABA) and Be-Vocal-for-Local(Mukul and Soni, 2020) considering normally locally available material is used for blade as well as handle of harvesting tool . Harvesting blade and made of high carbon locally known as hard Patti and Teak Sag Wood handle is used. Scientific reference available, the material geometry of the blade for enhancing the durability, performance, reducing efforts and existing Vikalp blade geometry considering the refinement of blade dimensions done.

As per Pandey and Devnani (1998) the values of ls/CS and lf/CS ratio for serrated sickle should be 0.4 and 0.8 respectively. According the length of cutting surface and chord length were optimized as 312 and 280 mm respectively. Hence, the CS/ CL ratio was obtained 1.11. The length of harvesting tool and diameter were optimized on the basis of anthropometric dimensions of women workers. As harvesting done with standing posture so 0.8 height (5^{th} percentile) of the acromial height of female worker was considered for designing purpose (Gite *et.al.* ,2009). As per the data collected the 5^{th}percentile value for of acromial height for female worker is 1168 mm. Distance of cutting crop considered 900 mm , from all this length of harvesting tool is obtained is 1300 mm.

The anthropometric and strength data of agricultural workers of region under ICAR Adhoc research project was used for optimizing the parameters. Handle length was optimized based on hand breadth at thumb and hand length. The 95th percentile of hand breadth at thumb was 95 mm and 5th percentile hand length 153 mm (*Aware et. al.,2016)*. The length of handle was kept as 150mm

The handle diameter was optimized on the basis of middle finger to palm grip diameter grip diameter (inside). The 95th percentile middle finger to palm grip diameter was 31 mm and the 5th percentile grip diameter (inside) was 39 mm The handle diameter was kept as 32 mm.

Performance Evaluation of Developed Harvesting Tool for Cutting Hybrid Napier

Five female workers who were familiar of harvesting of Napier grass and paddy with sickle by are involved in study (here after we call as subject). The information about experiment was given to subject so as to ensure their co-operation. Each subject was asked to rest for 30 minutes sitting in shade before actual harvesting. Heart rate values (in beats per minute) were recorded using Polar HR monitor (RS 300X).During resting period, after 20 minute of rest, the HR valus of the last 10 minute of rest were recorded, averaged and noted as resting HR for each individual subject. After the resting subject was asked to harvest Napier grass with improved harvesting tool for 50 minutes, during that period heart rate values were recorded. The average heart rate were for the further calculation and analysis.

Comparative ergonomic evaluation of harvesting tool with sickle were carried out to get rate of work (filed capacity) and heart rate work female workers.

Fig 2 : Female worker harvesting Napier grass with improved harvesting tool

Table 1 : Comparative performance of Improved harvesting tool compare to sickle

Sl. No.	Observation	Sickle	Improves harvesting tool
1	Capacity	100-125 m^2/h	100-160 m^2/h
2	Harvesting time body posture	Bending	standing
3	Chances of injuries	*Less but prolong bending posture fatique and little chances of hand injuries*	Very less chances
4	Field capacity	0.011 ha/h	0.013 ha/h
5	Harvesting cost per ha	3409 Rs/ha	2885 Rs/ha

The field capacity of improved harvesting tool was found to be 0.013 ha/h which was 18 percent higher than sickle (0.011 ha/h).

Table 2 : Ergonomic parameter for the harvesting tool operation

Sl. No.	Observation	Sickle	Improves harvesting tool
1	No. o f subject	5	5
2	Age of subjects	32	32
3	Weight, kg	43	43
4	Resting heart rate, bpm	84	84
5	Working Hr.bpm	148	136
6	Work pulse, bpm	64	50

The developed harvesting tool used for harvesting Napier grass , Daincha green manuaring crop , paddy it works satisfactory. During performance evaluation heart rate varies from 84to 136 beats for continuously 50 minute harvesting. Energy expenditure rate varies from 5 to 12.5 kcal/min. It can save 18 percent harvesting time with compare to conventional sickle. Light in weight (1.8 kg) and ergonomically suitable and comfortable for female farmers. The farm worker is not familiar with harvesting of this tool so promotion and working method will be promoted with extension by different organization.

Conclusion

The performance harvesting tool is better terms of field capacity and agronomical aspect. The silent features of harvesting tool is scientifically designed, work satisfactory so need to promote in all parts of country so female worker and fodder grower benefited by it.

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Computation of Topographic Factor of RUSLE using Derived High Resolution DEM

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Abstract: Indiscriminate use and mismanagement led to soil degradation which is an important global issue causing adverse impact on agricultural productivity, environmental quality and ultimately quality of human life. Water erosion is the major cause of soil degradation not only for India but for the world. Soil Loss Estimation models *viz.* USLE, RUSLE and MUSLE can be used to assess extent of soil erosion. Topographic factor of USLE models play a major role for gross soil erosion. In the present study, topographic factor of RUSLE was derived on a sub-watershed basis. The 20 m Digital Elevation Model was prepared by digitization of elevation points, contours and watershed boundary of selected sub-watershed using "Topo to Raster" interpolation method of spatial analyst tools into ArcGIS interface. The DEM resolution of 20 m was selected due to the fact that this is closest to 22.13 m slope length, which is used for the derivation of model components. USPED Model was used to derive slope length factor while slope steepness factor was derived separately for slope gradient < 9 and ≥ 9. The DEM indicates that most of the area has as elevation difference of 125 m which makes the topography highly susceptible to erosion due to overland flow. Reclassified slope length factor indicates that 95.50 % area of the sub-watershed having slope length value < 4, while only 0.50 % area having slope length factor values more than 4 which falls only on high altitudes hilly terrain. It could be inferred from the results that when value of L was more than erosion was more, in steep areas, where as when it was less, in plain topography, erosion was less. Reclassified slope steepness map indicates that 76.83 % of study area has slope steepness value less than 1.0 while it is greater than 1.0 only for 23.17 % of study area therefore average gross erosion value of study area was less. The estimated slope length factor and slope steepness factor of the study area were 1.19 and 0.78 respectively which indicates that the slope length factor is highly responsible for soil erosion in study region.

Keywords: *RUSLE, Slope length factor, Slope steepness factor, DEM*

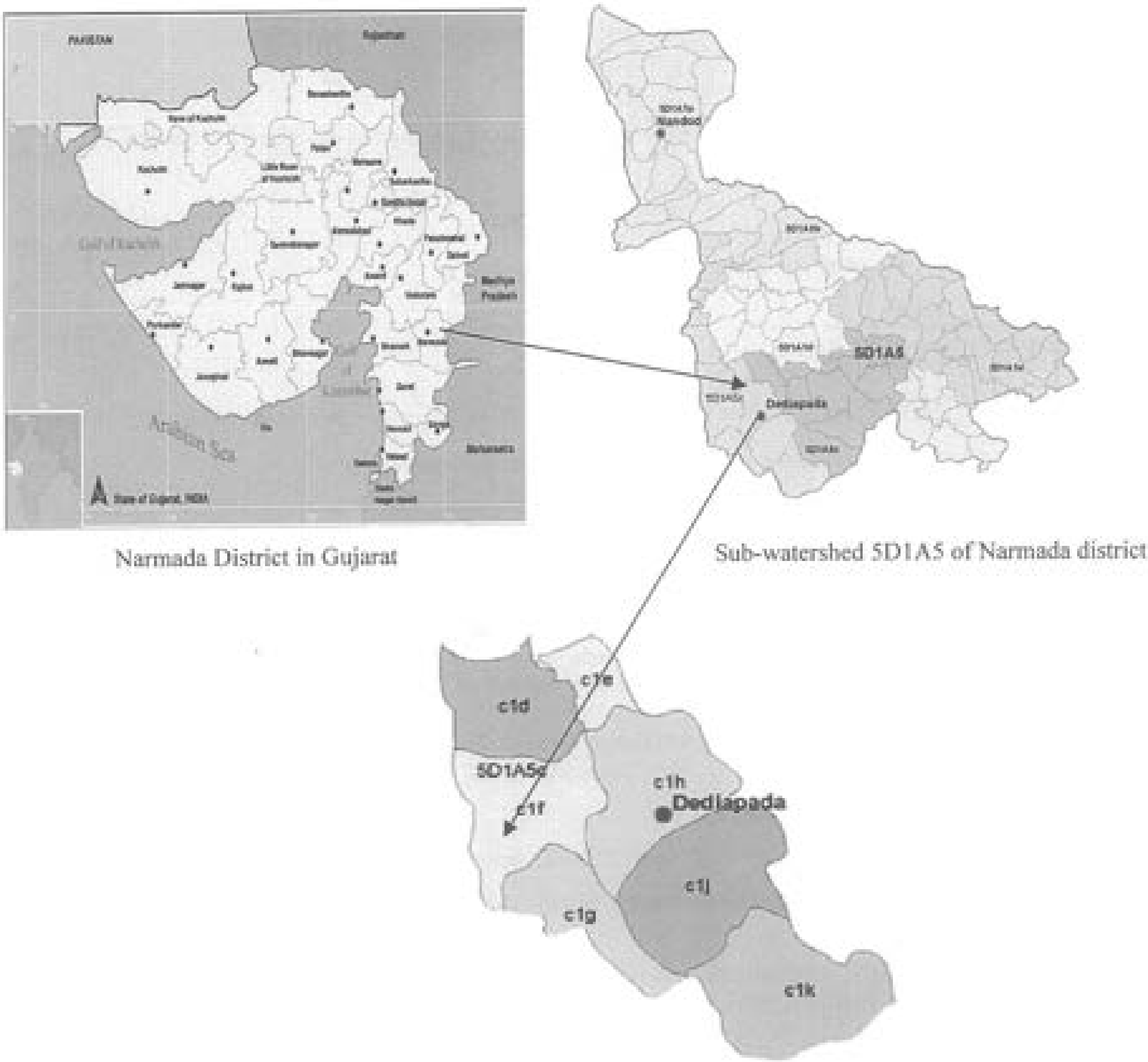
Introduction

World is under the threshold of food insecurity especially in the developing countries. Food and Agricultural Organization has issued forecasted about rising global hunger, if global population reaches 9.1 billion by 2050, the FAO says that world food production will need to rise by 70%, and food production in the developing world will need to be doubled. Indiscriminate use and mismanagement led to soil degradation which is an important g'obal issue causing adverse impact on agricultural productivity and environmental quality. About 33 % of land in the world has been affected by various form of land degradation and affects more than one billion people (Maji et al., 2010). Water erosion is the major cause of soil degradation not only for India but for the world. Soil Loss Estimation models *viz.* USLE, RUSLE, MUSLE, WEPP etc. can be used to assess extent of water erosion. Topographic factor of USLE models play a major role for gross soil erosion. In the present study, topographic factor of RUSLE was derived on a sub-watershed basis to analyse the weightage of topographic factor for gross soil erosion.

Materials and Methods

Location

Sub watershed that catches water from main stream of Dediapada region (Dist.-Narmada) was selected for the study purpose. The sub watershed lies between 73^0 31' 52.63" and 73^0 38' 58.02" East longitude and 21^0 33' 23.83" and 21^0 40' 14.18" North latitude. The sub watershed is located in the Survey of India toposheet no. F43N10. The study area covers 7710.64 ha. The location map of the sub-watershed is shown in Fig. 1. Based hierarchical system of watershed delineation, selected sub-watershed is given the number as 5D1A5c (Anonymous, 2014).



Narmada District in Gujarat

Sub-watershed 5D1A5 of Narmada district

Fig. 1: Location map of selected sub-watershed 5D1A5c

Slope Length Factor (L)

The L factor is the ratio of the actual horizontal slope length to the experimentally measured slope length of 22.13 m. Slope length is the distance from the point of origin of overland flow to either the point where the slope decrease to the extent that deposition begins or the point where runoff enters well defined channels (Wischmeier and Smith, 1978).

Unit Stream Power Erosion and Deposition (USPED) Model

In the USLE and RUSLE, L is dependent on linear distance λ which is the horizontal length from the start of sediment transport to any point on the slope. Thus, they are inherently a single dimensional function while in USPED model; the topographic factor represents the change in the transport capacity of the flow direction, being positive for areas with topographic potential for deposition and negative for areas with erosion potential (Mitasova *et al.*, 1996). The USPED uses the area of upland contributing flow at any point of distance. In this study, USPED Model was used to derive slope length factor.

The L calculation on a slope is shown in Equation 1,

$$L = (m+1)\left(\frac{\lambda_A}{22.13}\right)^m \qquad \text{...(1)}$$

Where, L is the slope length factor

λ_A is the area of upland flow,

22.13 is the unit plot length.

m is a variable exponent calculated from the ratio of rill-to-inter rill erosion, as described in equation 2.'

$$m = \frac{\beta}{1+\beta} \quad \ldots(2)$$

in which, β dependent on slope, It was computes using formula no. 3.

$$\beta = \frac{\sin\theta}{0.0896\,[3\,(\sin\theta)^{0.8}\ +0.56\,]} \quad \ldots(3)$$

The $m + 1$ comes from the fact that, in order to get a value for $L = \left(\frac{\lambda}{22.13}\right)^{m}$ that is considerate of the area of contributing upland flow on the slope up to any point i, we must integrate L over the interval $[0..i]$.

The Digital Elevation Model (DEM) is required to analyze the topographic properties of study area in order to estimate the slope length and slope steepness factor.

Digital Elevation Model (DEM)

Digital Elevation Model (DEM) represents the topography of area using GIS and since erosion is highly related with topography, by using DEM models, flow direction, flow accumulation; slope steepness; slope direction; flow length and flow pattern could be defined. The geo-morphological and hydrological consistency of a DEM is reached when the matrix image exactly represents the relief features, such as the hydro-graphic basin watershed, thalwegs and concave and convex elements, and it assures the convergence of the surface runoff for the mapped drainage network. Topo to Raster interpolation method generates a hydrologically correct DEM so it was used to generate the DEM of 20 m resolution.

The DEM was prepared adopting following procedure:

1. Topo-sheet "F43N10" was scanned using Colortrac SmartIf Gx+42 scanner.
2. Toposheet was geo-referenced into ArcGIS interface using latitude and longitude of the Toposheet by geo-referencing tools (Fig. 2).
3. For digitization of elevation points, contours and watershed boundary into ArcGIS catalogue, respective three shape files of points, poly-lines and polygon was prepared using Arc catalogue.
4. Then using editor tool, digitization of 20 m contours and elevation points from Toposheet was done (Fig. 3).
5. Shape file of sub watershed area "5D1A5c" under study was procured from BISAG, Gandhinagar.
6. Using "Topo to Raster" interpolation method of spatial analyst tools into ArcGIS interface, DEM of 20 m resolution was created using all three shape files, viz. contour, elevation points and watershed boundary. The DEM resolution of 20 m was selected due to the fact that this is closest to 22.13 m slope length, which is used for the derivation of model relations.

Spatial Analyst extension of ArcGIS interface was used to derive the 20 m resolution DEM in order to estimate slope length factor as described below.

1. Depression less DEM was prepared using "Hydrology-Fill" tool of Spatial Analyst extension.
2. Flow direction map from depression less DEM was prepared using "Hydrology – Flow Direction" tool of Spatial Analyst extension.
3. Flow accumulation map from flow direction map was prepared using "Hydrology – Flow Accumulation" tool of Spatial Analyst extension.
4. Slope map (in degree) was prepared from DEM using "Surface – Slope" tool of Spatial Analyst extension.
5. The raster layer for β component of exponent m was derived using eq. 3 by following algorithm using "Map Algebra - Raster Calculator" tool of Spatial Analyst extension.

   β = Float (sin (slope in degree)) / Float (0.0896*(3*Power (sin (slope in degree), 0.8 + 0.56))).

Fig. 5: Flow Directions Map

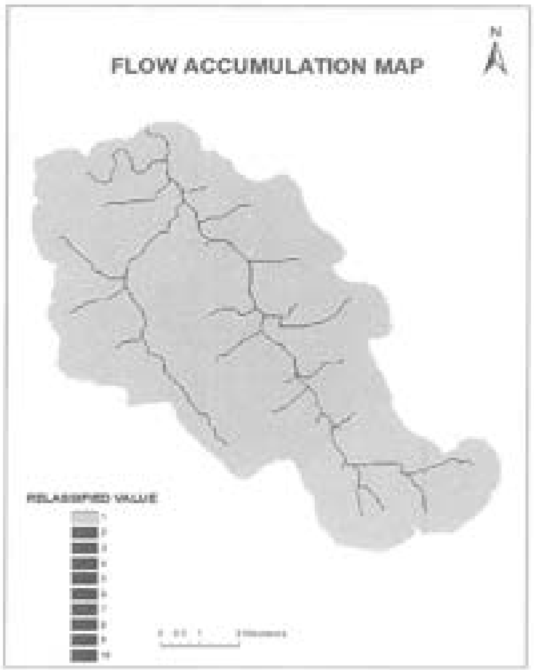


Fig. 6: Flow Accumulation Map

Rill to Inter Rill Erosion Ratio

Rill to inter rill erosion ratio is used as exponent 'm' to derive the slope length factor. The exponent m value was derived by using eq. 2 as shown in Fig. 7. The maximum value of exponent m is 0.44. The reclassified exponent m value map (Fig. 8) shows that 51.68 % area has value less than 0.10 while 25.01 % area have exponent m values between from 0.10 to 0.20. Though highest value of exponent is 0.44, but it is of very small area, whereas most of the area (77 %) has less than 0.20 values, therefore it shows that erosion susceptible covers less area (23%).

Fig. 7: Exponent m map

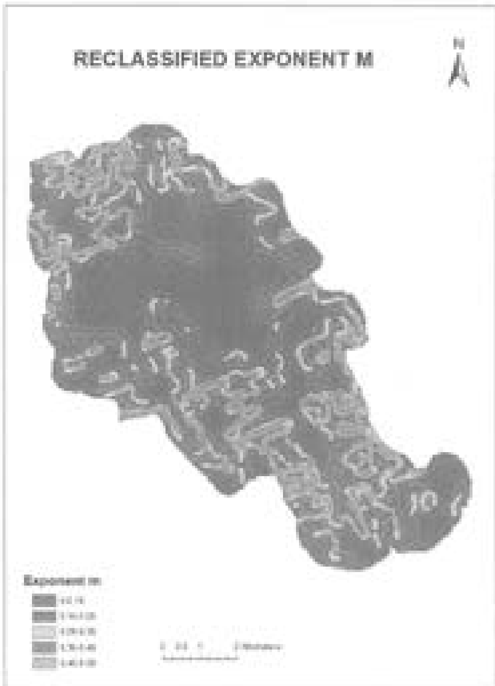


Fig. 8: Reclassified exponent m map

Fig. 9: Slope length factor map

Fig. 10: Reclassified slope length map

Slope Length Factor (L)

Fig. 9 describes the slope length factor at each grid cell of study area. The slope length factor value ranges from 0 to 15.58. Reclassified slope length factor (Fig. 10) indicates that 95.50 % (7672.28 ha) area of the sub-watershed having slope length value of less than 4, while only 0.50 % (38.35 ha.) area having slope length factor values of more than 4 which falls only on high altitudes hilly terrain. It could be inferred from the above results that when value of L was more than erosion was more, in steep areas, where as when it was less, in plain topography, erosion was less. Also, that exponent 'm' plays a major role in affecting L factor.

Slop Steepness Factor

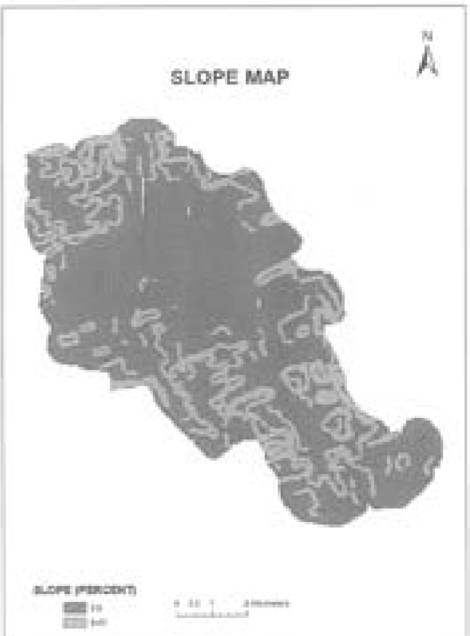


Fig. 11: Slope map in percent

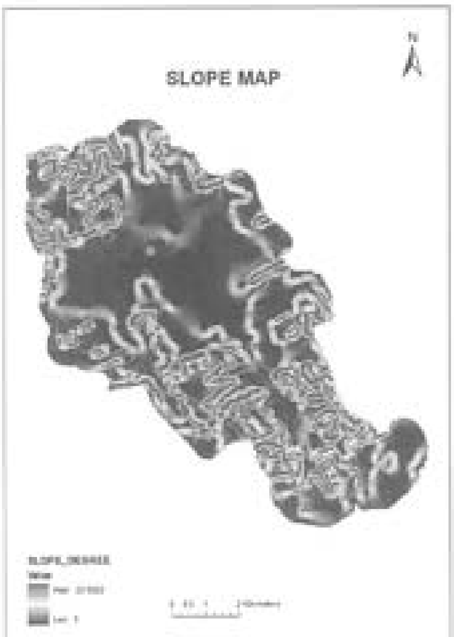


Fig. 12: Slope map in degree

Fig. 11 depicts the slope in percent, as shown in the figure, 5924.27 ha. (76.83 %) area has slope < 9 percent, so eq. 4 was used to compute the slope steepness for this area while 1786.37 ha. (23.17 %) area has slope ≥ 9 percent so eq. 5 was used to compute the slope steepness for that area.

The raster layer of slope map (in degree) as shown in Fig. 12 was used to calculate the slope steepness by using both the formula (eq. 4 and 5) separately. Attribute value of slope steepness for the resulting raster layer was transferred to the raster layer of Fig. 12 in order to get the final slope steepness map as shown in Fig. 13. Reclassified slope steepness map (Fig. 14) indicates that 76.83 % of study area has slope steepness value less than 1.0 while it is greater than 1.0 only for 23.17 % of study area therefore average gross erosion value of study area was less.

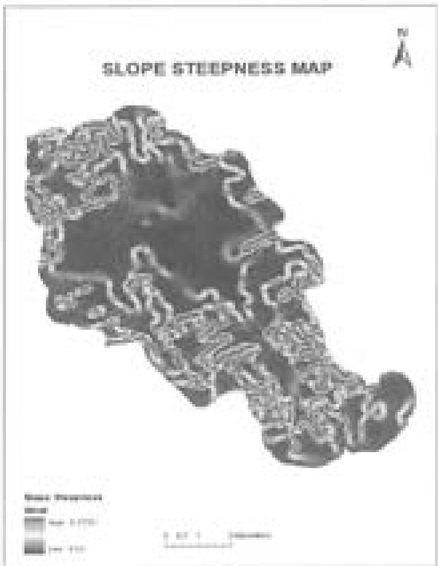


Fig. 13: Slope steepness factor map Fig.14: Reclassified slope steepness map

Conclusions

Reclassified slope length factor indicates that 95.50 % area of the sub-watershed has slope length factor value of < 4, while only 0.50 % area has slope length factor values of > 4 which falls only on high altitudes hilly terrain. Reclassified slope steepness map indicates that 76.83 % of study area having < 9 percent slope has < 1.0 of slope steepness value while 23.17 % of study area having ≥ 9 percent slope has slope steepness value ranges from 1.0 to 6.0. The estimated slope length factor and slope steepness factor of the study area were 1.19 and 0.78 respectively which indicates that the slope length factor is highly responsible for soil erosion in study region.

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Land Use Land Cover Dynamics in Dimapur District with Special Emphasis on Shifting Cultivation in Nagaland Using Geospatial Techniques

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Abstract: Land cover refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Land use refers to the way in which land has been used by humans and their habitats (such as agriculture, settlements, industry etc.).In the present study Multi-temporal LANDSAT TM satellite images of 2010-11 and 2018-19 has been used to map the changing pattern of LULC of Dimapur district, Nagaland from 2010 to 2019. Land use land cover in this study is largely determined by built up, agriculture, forest, barren lands, wetlands and water bodies. The overall change in agricultural areawas 4584.78 ha from 15.5 % (2010-11) to 16.4 % (2018-19). The biggest change was observed in built up (5%) and forest had a decrease of (-1.9%). Barren/ unculturable waste land decreased from (10.7 %) in 2011-12 to (8.8%) 2018-19. There is a decrease in water bodies (-1.98%). In particular, there has been an increase in agriculture and built up whereas barren land, water bodies and forest cover has declined. Shifting cultivation area in Nagaland decreased from 96570 ha (2010-11) to 91040 ha (2018-19) which is a good sign. Various conservation measures both traditional and engineering measures are adopted to reduce soil loss by shifting cultivation in the state and also for the reduction of shifting cultivated area in the long run.

Keywords: Land use, Land cover, Shifting cultivation, Remote sensing and GIS

Introduction

Land cover refers to the physical characteristics of Earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Landuse refers to the way in which land has been used by humans and their habitats (such as agriculture, settlements, industry etc.).

The potential of satellite-based data as a basis for generating valuable information for LULC is by now widely recognized although initial efforts was made since mid-seventies for application of different interpretation techniques in LULC mapping (Anderson, 1976). Over the last few decades various techniques of LULC mapping and change detection have been advanced and applied all over the globe Land-use/cover is widely determined by the ecological conditions, altitudes, geological structure and slope along with technological, socio-economic and institutional set-up, which also influences the land-use pattern (Rai et al., 1994).

In the present study Multi-temporal LANDSAT TM satellite images of 2010-11 and 2018-19 has been used to map the changing pattern of LULC of Dimapur district, Nagaland from 2010 to 2019. All theimages were downloaded from USGS earth explorer website(http://earthexplorer.usgs.gov/).Land use land cover in this study is largely determined by built up, agriculture, forest, barren lands and water bodies.

Nagaland, a North Eastern state of India located (between 25° 62"–27° 42" N latitude and 93° 20"–95°15" E) falls under the Easter Himalayan Biodiversity Hotspot of the world. With an area of 16,579 km^2 it has a total population of 1,980,602 (2011 census). It is bordered by Myanmar on the east; and by Arunachal Pradesh, Assam and Manipur on the north, west and south, respectively.

Nagas have managed the mountainous land through shifting cultivation, which is rain fed and sustains the agro-bioresource. Shifting cultivation also known as Jhum, Swidden orSlash and Burn constitutes about 59% of the annual total net cultivated area in the state. Jhum land for crop cultivation is burned in the late February and march, followed by sowing of rice (major crop) in the month of April and early May. Weeding is done thrice and the crop is harvested in the month of late September and October. However, in many villages radical change from traditional to commercial crops are taking place as a result of the initiatives and efforts taken by the Government. In whole, the farming community has responded to the changing consumption patterns by diversifying its production portfolio towards high value food commodities. According to state land records, the total area under agriculture in a given year accounts to 2, 22,787 ha, which is 13.44 % of the total land area. The net area under Jhum cultivation in the year 1985–86 in the state was 99,345 ha, which decreased to 78,000 ha (1995–96) and increased from 86,000 ha (2000–01) to 96,570 ha in (2010–11). In the year 2018-19 there was a decrease in the cultivation area with 91,040 ha.

Objectives

(i) To identify the long-term trend of change in Land use land cover classification from 2010-11 to 2018-19

(ii) To assess temporal dynamics of shifting cultivation in the different districts of the state.

Materials and Methods

Study area

Nagaland is the 16th state of India and is one of the 'Seven Sisters' of the North East Region. The state is bounded by Assam on the West, Myanmar on the East, Arunachal Pradesh and part of Assam on the North and Manipur on the South. It covers a geographical area of 16,579 km^2 and lies between 25°60' and 27°40' Latitude North and 93°20' and 95°15' Longitude East of the Equator. The altitude ranges from 100 m to 3840 m with a climatic condition varying from sub-tropical to sub-temperate. The annual rainfall varies from 1500- 2500 mm occurring over about 7 months from April to October. The temperature ranges between 4°C to 35°C.

Dimapur is located in the southwest of Nagaland. Dimapur is the 8th district of Nagaland established on December 1997 and liesbetween 25°48"and 26°00" North latitude and 93°30" and 93°54" East longitude. Thedistrict is bounded by Assam on its North and West, Kohima on the East and PerenDistrict in the South. The annual rainfall is 1560 mm and the average temperature is 24.0°C.

Data assessment

Digital data for the present study, LANDSAT 7 ETM + C1 Level-1 (Path-136 and row-42) was used for the year 2011-12 and LANDSAT 8 OLI/TIRS C1 Level-1 (Path-135 and row-42) was used for the year 2018-19 which wasprocured from USGS, earth explorer website (Table 1). The images were used for identification andclassification of land use land coveragriculture, builtup, barren lands, forest and wetlands in the study area. The LULC maps were then generated using QGIS 3.14.The training samples were selected for eachof the land use types by delimiting polygons aroundrepresentative sites. Using the pixels enclosed by thesepolygons, spectral signatures for the respective land userecorded by the satellite images were derived. In this study supervisedmaximum likelihood method, was used as the classificationmethod.

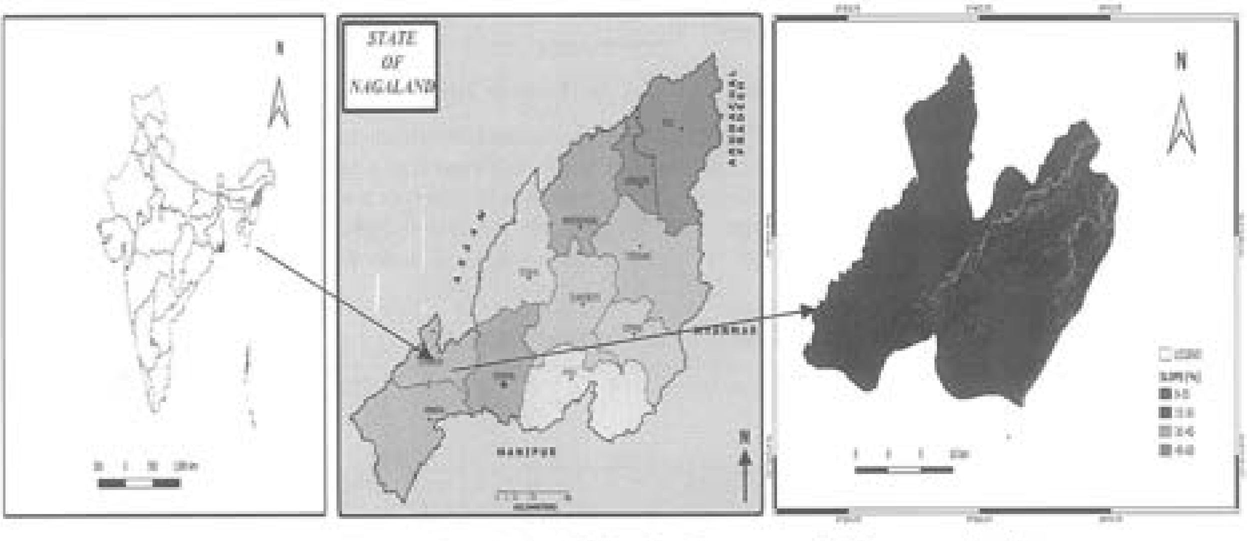

Fig. 1 : Location of Nagaland state and Dimapur district.

Results and Discussions

LULC status

To know the long-term spatial and temporal change inland use of Dimapur district, five primary land use land cover types viz. Agriculture (crop land, current shifting cultivation, fallow, plantation), barren or waste lands (barren/ rocky, scrub lands), built up (mining, rural, urban), forest (deciduous, forest plantation, scrub forest), wetlands/water bodies (rivers, streams, canals) were delineated using topographic sheets for the year 2010-11 and 2018-19 (Table 2). The spatial distributionof land cover is given in Fig. 2 and3and temporal changes inland uses are given in Table3.

Results from the classified images indicated that in 2010-11 area occupied by different classes viz. agricultural land was about 15.5 %, barren/waste lands was 10.7 %, built up covered 20 %, forest occupied most part of the district and covered about 47.6 %, and water bodies occupied 6.1 %. On the other hand, in 2018-19about 16.4 % ofthe area was covered by agricultural land against 15.5 % area in 2010-11 showed a increase in cultivated land.Barren land and built-uparea covered 8.8 % and 25 % respectively while, foresthad largest share of 45.7 %. The areacovered by water bodies was 4.12 % of the total geographical area.

Table 2:Description of different LULC categories

Sr. No.	LULC class	Description
1	Agriculture	Crop land, current shifting cultivation, fallow, plantation
2	Barren/waste lands	Areas devoid of vegetation i.e barren/ rocky, scrub lands
3	Built up	Mining, rural, urban
4	Forest	Deciduous, forest plantation, scrub forest
5	Wetlands/water bodies	Rivers, streams, canals

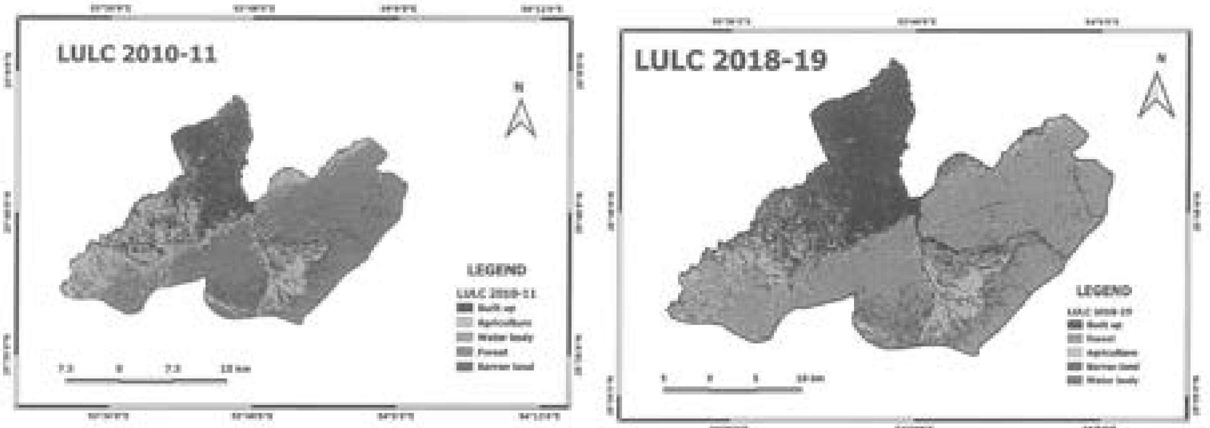

Fig. 2 : Spatial distribution of different LULC in the year 2010-11 and 2018-19

Nagaland is rich with natural biodiversity and about 50% of the state is covered in forests. In Dimapur district forest covered around 47.6% (2010-11) and 45.7% (2018-19) of the total study area. A slight decrease was observed in forest (-1.9%) which is due to deforestation, urbanization and increase in population evidently. And hence there was an increase in built up (5%).The highest change was observed in built up (5%) with a coverage of 18570.15 ha(2010-11) with 20% of TSA and 23154.93 ha (2018-19) with 25% of TSA. Barren land had a decrease of (-1.9%). There is an decrease in water bodies (-1.98%). A column chart representing the change in the LULC classes from 2010-11 to 2018-19 is shown in Fig 4.

Table 3: LULC change in Dimapur district

LULC class	Area (ha) (2010-11)	%TSA (2010-11)	Area (ha) (2018-19)	% TSA (2018-19)	Change in area (ha)	Change in area (%)
Agriculture	14351.2	15.5	15186.33	16.4	4584.78	0.9
Barren lands	9925.74	10.7	8165.19	8.8	-1806.26	-1.9
Built up	18570.15	20	23154.93	25	835.13	5
Forest	44173.49	47.6	42367.23	45.7	-1760.55	-1.9
Water bodies	5679.42	6.1	3826.32	4.12	-1853.1	-1.98
Total	92700	100	92700	100		

Negative (−) sign indicates decreasing change and positive (+) sign indicates increasing change

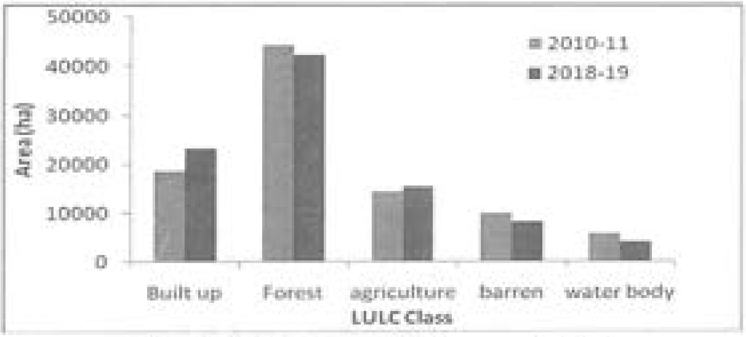

Fig. 4 : LULC change in Dimapur district

Shifting cultivation in different districts of Nagaland

Nagaland has 12 administrative districts viz Dimapur, Kohima, Phek, Mokokchung, Tuensang, Mon, Wokha, Zunheboto, Peren, Kiphire, Longleng and Noklak. Noklak is the youngest and the 12th district of Nagaland state. It was established on 21st December 2017 which is why various datas are still not available for the district. Table 4 represents the shifting cultivation area in various districts of Nagaland for the year 2010-11 and 2018-19 excluding the Noklak district.

Table 4: Jhum cultivated area in different districts of Nagaland in 2010-11 and 2018-19 (www.statistics.nagaland.gov.in)

Jhum cultivated area in different districts	Cultivated Area (Ha) (2010-11)	Production (MT) (2010-11)	Cultivated Area (Ha) (2018-19)	Production (MT) (2018-19)
Dimapur	9620	17170	9070	18040
Kohima	9880	17820	5150	10240
Phek	1960	3400	1640	3260
Mokokchung	11670	21000	9320	18550
Tuensang	11490	20810	10050	19980
Mon	9800	17680	15930	31700
Wokha	11670	21200	10080	20060
Zunheboto	9720	17170	9230	18370
Peren	4470	7980	6320	12550
Kiphire	9080	16400	8450	16810
Longleng	7210	12920	5800	11520
Nagaland	96570	173830	91040	181080

From the table it is observed that in the year 2010-11, Wokha and Mokochung district had the highest jhum cultivated area with 11670 ha with production of 21200 MT and 21000 MT respectively.However, in the year 2018-19 the highest jhum cultivated area was observed in Mon district with 15930 ha with production of 31700 MT. Phek district had the least area of 1960 ha and 1640 ha in the year 2010-11 and 2018-19 respectively. All the districts have shown a decrease in the cultivated area except for Mon and Peren with an increase from 9800 ha to 15930 ha and 4470 ha and 6320 ha respectively. Overall, the state Nagaland itself has shown a decrease in the cultivated area from 96570 ha to 91040 ha. Government initiatives, awareness among the farmers, public distribution system (PDS) and growth of industry has given options to the farmers to wean away from shifting cultivation (Adhikary*et al.* 2018). The decline in shifting cultivation area is a good sign. But elsewhere in India the shifting cultivation is spreading with an alarming rate.

Table 5: District wise total population and literacy rate of Nagaland according to 2011 census (www.statistics.nagaland.gov.in)

SN	District	Total population	Literacy Rate (%)
	Nagaland	19,78,502	79.55
1	Kohima	2,67,988	85.23
2	Dimapur	3,78,811	84.79
3	Phek	1,63,418	78.05

4	Mokokchung	1,94,622	91.62
5	Wokha	1,66,343	87.69
6	Zunheboto	1,40,757	85.26
7	Tuensang	1,96,596	73.08
8	Mon	2,50,260	56.99
9	Peren	95,219	77.95
10	Kiphire	74,004	69.54
11	Longleng	50,484	72.17

From Table 5 the relationship between shifting cultivation with respect to literacy rate in various districts of Nagaland is noticeable. Mon district with the least literacy rate of 56.99% had an increase of cultivated area from 9800 ha in 2011-12 to 15930 ha in the year 2018-19. Mokokchung district with the highest literacy rate of 91.62% had a decrease of cultivated area from 11670 ha to 9320 ha.An increasing trend was also seen in Peren district (77.95% literacy rate) from 4470 ha to 6320 ha.

Conservation measures within the shifting cultivation

Over the past two decades, due to increasing human population, the jhum cycle which extended to 20-30 years in older days, has now been reduced to 3-6 years. Since a huge number of tribalfarmers are involved in this cultivation, therefore complete eradication of this method is practically impossible. In Nagaland, considerable area is under barren,and shifting cultivated land. If left unprotected, these lands will become severely degraded in the near future.These lands can be used for cultivation in a sustainablemanner by adopting suitable soil and water conservationmeasures and following scientific method of cropcultivation.

- Contour bunds by using wooden log (locally known as 'Echo') were constructed to prevent soil loss. Pits were made to plant fruit crops and some pits were left to use these as a water recharge trench (Chaterjee et al.2013).
- Adhikary et al. (2017) identified that the hedge-row intercropping can reduce the menace of land degradation without compromising with the food grain production in sloping lands.
- Practicing jhum in highly sloped lands should be stopped. Plantation of tree species could be the best option for such lands. (Chaterjee, 2012)
- To make jhum sustainable (Pangging and Arunachalam,2008) proposed to develop criteria and indicators (C and I) for the jhum system for the North Eastern states. This includes a third-party monitoring and assessment of the management practice to reduce the adverse effect of jhum cultivation and also to help the indigenous community to sell the products that may have more market value as well, due to its organic nature.
- Increase in the jhum cycle can be considered as an alternative against the existing one. For this, intensive extension activities including awareness programmes are required (Chaterjee, 2012)
- Practice of Integrated Farming System (IFS) in jhum cycle can be advocated to augment the productivity and sustainability of the whole system. For instance Rathore and Bhatt (2008) observed that the rice- vegetable pea-beans cropping system was the most suitable under jhum land of Nagaland and integration of fish, pig, dairy, cattle, duck, and the other crops such as rice, vegetable pea and beans showed maximum system productivity,i.e., 126.5 t ha^{-1} (rice equivalent yield), followed by cultivation of rice, vegetable pea and beans along with dairy cattle (free grazing), having system productivity of 105.0 t ha^{-1}.
- In different parts of North Eastern India, the land is often abandoned after first year of jhum cropping, and second year cropping is sometimes practiced with plantations of banana and pineapple (Kushwaha and Ramakrishnan 1987). Tawnenga and Tripathi (1996) hypothesized that if second year cropping on jhum fields is essentially introduced, the dependence of the shifting cultivators on the forest could be reduce to almost one-half. They suggested that the combination of inorganic and organic manuring is more suitable to improve economic yield during second year cropping.

Ongoing programmes on *jhum* improvement

- Integrated land development projects under DSCO, Govt. of Nagaland.
- Integrated watershed development project under DSCO, Govt. of Nagaland.
- Soil and water conservation programme under RKVY under DSCO, Govt. of Nagaland.
- ICAR- projects on jhumimprovement under TSP project

Conclusions

The determined LULC mapping overall accuracy of approximately81%and 80% for 2010-11 and 2018-19 respectivelydetermined indicates that the integration of visual interpretationwith thematic mapping of remotesensing imagery is an effective method for the identificationof changes in LULC.The overall change in agricultural areawas 4584.78 ha from 15.5 % (2010-11) to 16.4 % (2018-19). The biggest change was observed in built up (5%) and forest had a decrease of (-1.9%). There is a decrease in water bodies (-1.98%).These maps could be used for comparing and finding an approximate area of various LULC classes in Dimapur district.

In the year 2010-11, Wokha and Mokochung districtwith 11670 ha and in 2018-19 Mon district with 15930 ha had the highest jhum cultivated area.Phek district had the least area of 1960 ha and 1640 ha in the year 2010-11 and 2018-19 respectively.Overall, the state Nagaland itself has shown a decrease in the cultivated area from 96570 ha (2010-11) to 91040 ha (2018-19) which is a good sign. This compilation can be used for studying the status and effects of jhum cultivation in Nagaland.

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Performance Evaluation of Biogas Purification System Using Different Dry Absorbent

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Abstract: A biogas is produced through anaerobic fermentation process of an organic matter which contains CH_4, CO_2, H_2S and other gases. The dry absorbentbased biogas purification system was developed and its performance was evaluated. The performance of the purification unit was evaluated for purification of biogas at bed heights of 15 cm, 20 cm and 25 cm with maintaining flow rates of 1.2 m^3/h, 1.5 m^3/h and 1.8 m^3/h. The response parameters investigated using design expert software and fixed per cent CH_4, per cent CO_2, concentration of H_2S, purification efficiency (CH_4), removal efficiency (CO_2), removal efficiency (H_2S). The two variable three level central composite model of response surface methodology in Design Expert Software was used to optimize purification unit parameters. The purification unit was observed to perform best at the optimum bed height 20 cm, flow rate of 1.5 m^3/h with concentration 67.71 per cent CH_4, 32.87 per cent $CO_2$and 164 ppm of H_2S. The purification efficiency (CH_4) 16.96 per cent, removal efficiency (CO_2) 23.23 per cent, removal efficiency (H_2S) 88.02 per cent was observed. For further removal of CO_2 water spraying and packed bed water scrubber were developed, which was found to be effective for removal of CO_2.

Keywords: Biogas purification system, CO_2 scrubber, H_2S scrubber, Limestone crystal, Iron turnings.

Introduction

Biogas is a clean renewable energy source for rural India. It mainly consists of methane (55-70%), carbon dioxide (30-45%), hydrogen sulphide (<1%) and some traces of water vapour, hydrogen sulfide, nitrogen, oxygen, ammonia, chlorinated organic matter, volatile phosphorous substances and other volatile trace compounds. Natural gas has 75-98% methane with small percentage of ethane, butane, propane whereas biogas contains about 60% methane and 40 % Carbon Dioxide. It is possible to improve quality of biogas by enriching its methane content up to the natural gas. Methane is important constituent present in raw biogas and is combustible. Raw biogas contains so many impurities among which removal of Carbon dioxide, Hydrogen Sulfide and moisture are important for upgrading biogas for various application.

The presence of H_2S in biogas, after combustion produces SO_2 which is Corrosive to metal parts i.e. regulators, gas meters, valves and mountingsexhaust pipes of burners, gas lamps and engines. The gaseous SO_2 also dissolves in engine oil causing the oil to become acidic and lose its ability to lubricate, damaging the engine and shortening time between oil changes. $SO_2$is considered more dangerous than H_2S because it is hazardous for health and environment, as it produces smog and acid rain.

The Carbon dioxide is present in raw biogas with very high concentration. This decreases energy content per unit mass /volume and limits its use for low quality energy applications. Presence of Carbon dioxide in biogas makes it undesirable to use it as a vehicular fuel because it lowers the power output from the engine and occupies additional space in gas storage cylinders. This may require frequent refilling of fuel tank of vehicle. Presence of carbon dioxide in biogas can cause problem of freezing at valves and metering points.

The animal waste i.e. cow dung can be used to generate biogas. Local agricultural waste can also be added along with cow dung for biogas production. Limestone crystals has property to absorb CO_2 from the biogas, Iron turnings/chips reacts with H_2S gas present in the biogas and silica gel absorb the moisture in the biogas and act as a dehumidifier these properties can be used to purify the biogas and thus increase its calorific value.

Materials and Methods

The experiment was conducted by using biogas purification system. The 20 cubic meter modified Janta biogas plant at Department of AH&DS, Dr. PDKV Akolawas used for present study. This biogas plant has feeding capacity of 500 kg cattle dung and 500 liter water.The generated biogas was used in the purification system and purified biogas was analyzed.The biogas purification unit consisted of two PVC pipes holding various absorbents. The absorbents i.e. limestone crystals, iron turnings and silica gel were placed in the absorbents holding cylinder at varying bed height as desired for the experimentation.The purification system and process parameters were optimized by conducting the trials using different flow rates and bed thickness/height. The developed biogas purification system was tested as per standard procedures for combination of various treatments by using

Design-Expert software.The independent factors viz. bed height and flow rate were kept within range while the responses viz. Purification efficiency, Removal efficiency (CO_2), Removal efficiency (H_2S), percent CH_4 was kept maximized and percentage CO_2, concentration of H_2S was kept minimized.The gas concentration of raw biogas and purified biogas along with flow rate and pressure was checked hourly. The gas purification efficiency and removal efficiency was calculated by using the following formula(Cheng-Chang 2014):

$$\text{Purification efficiency}, CH_4\ (\%) = \frac{(B-A)}{A} \times 100$$

where, A& B – The concentration of CH_4 (before and after scrubbing) (%),

$$\text{Removal efficiency}, CO_2\ (\%) = \frac{(A-B)}{A} \times 100$$

where, A & B – The concentration of CH_4 (before and after scrubbing) (%),

$$\text{Removal efficiency}, H_2S\ (\%) = \frac{(A-B)}{A} \times 100$$

where,A & B – The concentration of H_2S(before and after scrubbing) (%),

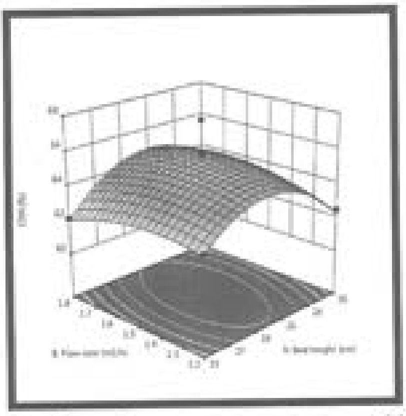
Results and Discussion

Optimization of process parameters

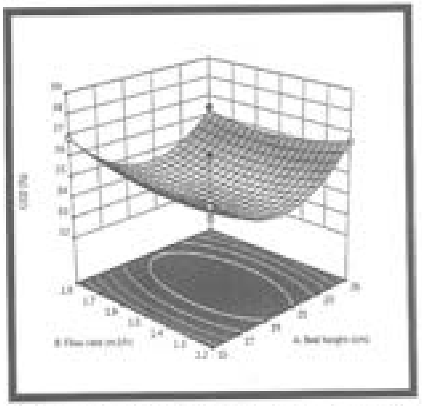
The data was generated on the parameters of gas flow rates and bed height. General design for removal of carbon dioxide and hydrogen sulphide from biogas in purification system has been worked out and analyzed by design expert model. The results obtained on various trials of the purification system at various gas flow rates and bed height condition were analyzed. Total 13 runs i.e treatments were analyzed as designed by the software. The following result was obtained:

Table: Effect of bed height and flow rate on dependent parameters

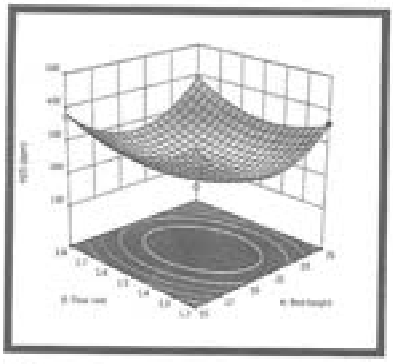
Std	Run	Bed height, cm	Flow rate, m^3/h	CH_4 %	CO_2 %	H_2S ppm	Purification Efficiency (CH_4)	Removal Efficiency (CO_2)	Removal Efficiency (H_2S)
7	1	20	1.07	63.91	35.01	317	13.28	19.53	76.09
6	2	27.07	1.5	61.21	37.79	421	7.57	12.09	66.37
13	3	20	1.5	62.98	36.02	221	15.43	21.01	83.79
8	4	20	1.92	64.01	34.99	343	13.01	19.1	75.30
3	5	15	1.8	62.13	36.87	374	9.80	15.12	71.68
1	6	15	1.2	62.99	36.01	399	10.24	15.77	70.61
4	7	25	1.8	63.57	36.43	394	12.07	15.92	69.55
12	8	20	1.5	65.81	33.19	207	15.89	22.63	85.07
11	9	20	1.5	67.71	32.87	164	16.96	23.23	88.02
2	10	25	1.2	62.44	36.56	361	7.98	13.08	73.19
9	11	20	1.5	65.21	33.79	197	14.78	19.93	85.25
10	12	20	1.5	66.11	33.87	273	15.23	19.01	78.75
5	13	12.92	1.5	60.79	38.21	454	5.32	11.5	63.20



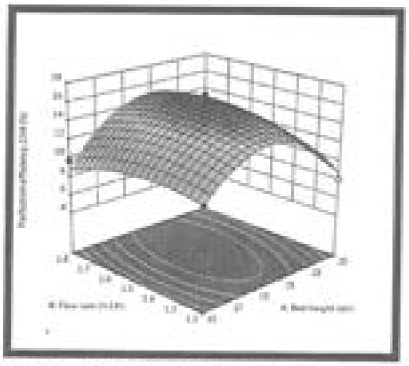
Fig(a) Effect of process parameters on CH_4%



Fig(b) Effect of process parameters on CO_2%



Fig(c) Effect of process parameters on H_2S, ppm



Fig(d) Effect of process parameters on purification efficiency(CH_4)

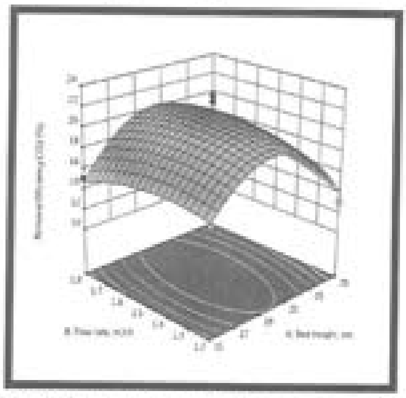
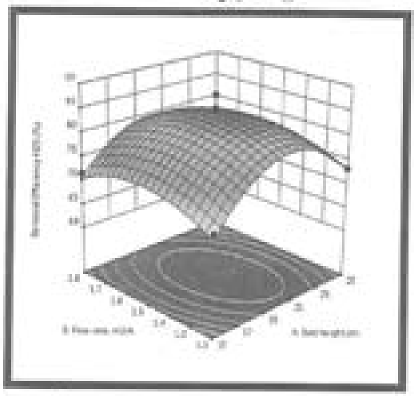


Fig (e) Effect of process parameters on removal efficiency (CO_2)



Fig(f) Effect of process parameters on removal efficiency (CO_2)

The impurities were found to be decreasing with increase in bed height and flow rate, which may be due to the fact that as the bed height is increased at initial level the gas comes in contact with sufficient quantity of absorbent hence increase in the reaction with the absorbent occurs which thereby results in decrease in impurities which result in higher CH_4 %, higher Purification efficiency (CH_4), lower CO_2%, lower H_2S %, lower Removal efficiency (CO_2 and H_2S)but with further increase in bed height, the impurities were found to be increasing which may be due to the fact that as the bed height increases above a specific level due to more crowding of particles the absorbents creates resistance to flow of gas and amount of gas passed is non uniform thereby resulting in uneven reaction with the absorbents thereby increasing the impurities, which results in lower CH_4 %, lower Purification efficiency (CH_4), higher CO_2%, higher H_2S %, lower Removal efficiency (CO_2 and H_2S). Thus the bed height was found to be optimum at 20 cm.

The impurities were also found to be decreasing with increase in flow rate. At minimum flow rate the impurities were found to be more which may be due to fact that as the flow rate was reduced, the impact of gas molecules on the absorbents is less thereby resulting in more impurities and lower CH_4 %, lower Purification efficiency, higher CO_2%, higher H_2S ppm, lower removal efficiency (CO_2 and H_2S). As the flow rate was increased, the impurities were found to be decreased upto a certain level after which even with the increase in flow rate the impurities were found to be increased. At maximum flow rate the impurities were found to be increased which may be due to the fact that at maximum flow rate the gas gets less time to react with the absorbents thereby resulting in more impurities andlower CH_4 %, lower Purification efficiency, higher CO_2%, higher H_2S ppm, lower removal efficiency (CO_2 and H_2S).Thus the flow rate was found to be optimum at 1.5 m^3/h.

Table : Optimized variables and their predicted responses for purification of biogas

Variable	Optimized Value	Responses	Predicted Value
Bed Height, cm	20.126	CH_4 %	65.56
Flow rate, m^3/h	1.502	CO_2 %	33.94
		H_2S (ppm)	212.30
		PE CH_4, %	15.67
		RE CO_2,%	21.16
		RE H_2S, %	84.18

The optimum value of different variables for purification were found to be in the range considered in the study.The superimposed contours of all the responses for bed height cm, flow rate m^3/h along with their intersection zones for maximum purification efficiency CH_4, removal efficiency $CO_2$and removal efficiency H_2S and CH_4 percent, minimum CO_2 percent and H_2S indicated the range of optimum values of process variables.The optimum values obtained from superimpose contours in the range were given below:

1. Bed height, cm : 18.75-21.26
2. Flow rate, m^3/h : 1.36-1.65

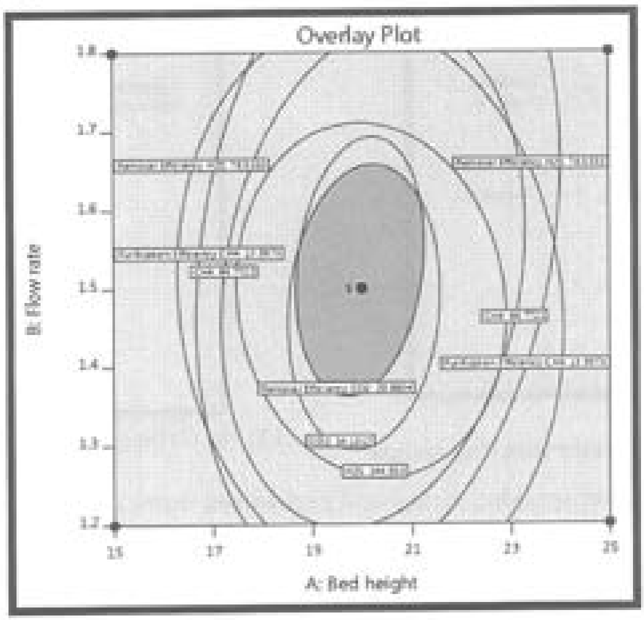


Fig. Superimposecontours for responses and their intersection for maximum purification efficiency

Modification for reducing CO_2 concentration

After the statistical analysis, it was observed that for the purification unit using dry absorbents, the optimum value for CH_4 %, CO_2 %, H_2S ppm, purification efficiency, removal efficiency (CO_2&H_2S) was observed at 20 cm bed height and 1.5 m^3/h biogas flow rate. The effect of dry absorbents was not much significant on the CO_2 removal. Hence, a water scrubbing system was developed for CO_2 removal. Two methods were usedi.e water spraying and packed bed water scrubbing system.

Water spraying:

The water spraying system consisted of a PVC pipe of diameter 152.4 mm and height 762 mm. The pipe has end caps attached at top and bottom end. The biogas flows from bottom to top. The inlet and outlet for biogas flow and water flow were installed in the system (Fig a). The water was sprayed using a water sprayer of height 150 mm and diameter 12.7 mm with pores of diameter 1 mm for water spraying. The water sprayer was installed at the top of the system, which sprayed the water in downward direction. The gas inlet was at the bottom of the system. The flow of gas and water was counter flow. The water and the biogas come in contact at the CO_2 purification chamber. The molecules of CO_2 were absorbed by the water, since CO_2 is soluble in water. The purified biogas was collected at the gas outlet at the top and analyzed. The water sprayed from the top was collected from the bottom outlet. The water was recirculated and used for purification. The results obtained at optimum levels of flow rate 1.5 m^3/h for CO_2% concentration.

Packed bed water scrubbing system:

The results obtained by water scrubbing were not much significant as desired result. Therefore, efforts were made to modify the water spraying unit. The water spraying unit was modified to packed bed water scrubbing unit (Fig b). The sprayer was removed, the water scrubbing unit was filled with gravels of varying size and water was filled in the PVC pipe upto 60 percent of the total volume. This was done by considering the amount of load sustained by the pipe. After filling the water in the system, it was closed at the top by end cap. The biogas was allowed to flow from the gas inlet at the bottom. The gas passed through the packed bed water scrubber and the purified gas was collected from the gas outlet at the top and was analyzed. The results were obtained at optimum levels of flow rate 1.5 m^3/h for CO_2 per cent concentration.

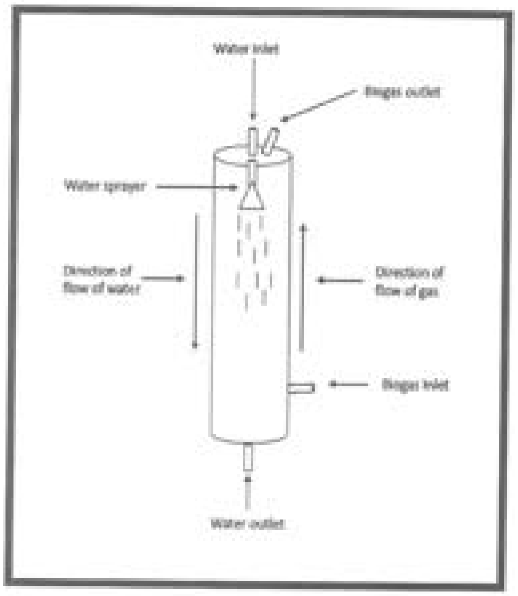


Fig (a)Orthographic view of water spraying system

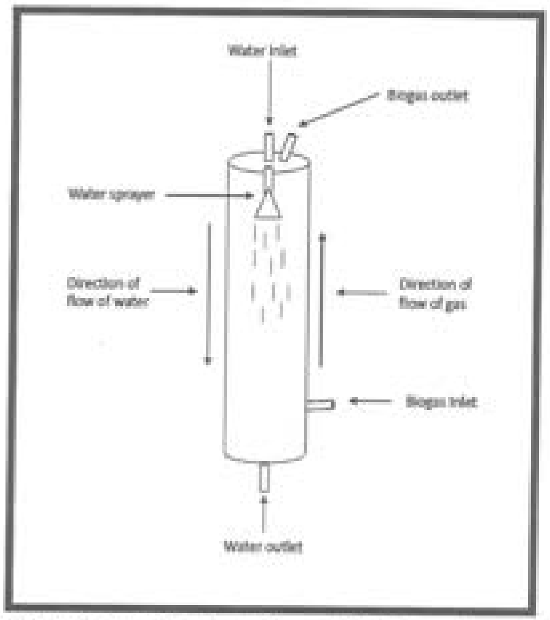


Fig (b) Orthographic view of packed bed water spraying system scrubbing system

Table Effect of water spraying system and packed bed water scrubbing system on CO_2 %

Observations	Water Spraying system		Packed bed water scrubbing system	
	CO_2, % (Before)	CO_2, % (After)	CO_2, % (Before)	CO_2, % (After)
1	36.02	28.27	36.02	19.37
2	33.19	26.17	33.19	21.07
3	32.87	27.71	32.87	18.67
4	33.79	25.08	33.79	19.90
5	33.87	26.68	33.87	18.11

The comparative study of all the three systems used for CO_2 removal

The comparative study for all the three system at optimized value i.e. 1.5 m^3/ h gas flow rate was carried out. From the study it was concluded that the packed bed scrubber had the most effective results for CO_2 removal, followed by water sprayer and dry absorbent respectively. This may be due to the fact that in packed bed scrubber the due to packing material, the residence time of gas was more which resulted in more removal of CO_2 as compared to water sprayer. In the dry absorbent, the gas didn't react with the limestone crystals significantly. Hence the packed bed water scrubber was most effective for CO_2 removal.

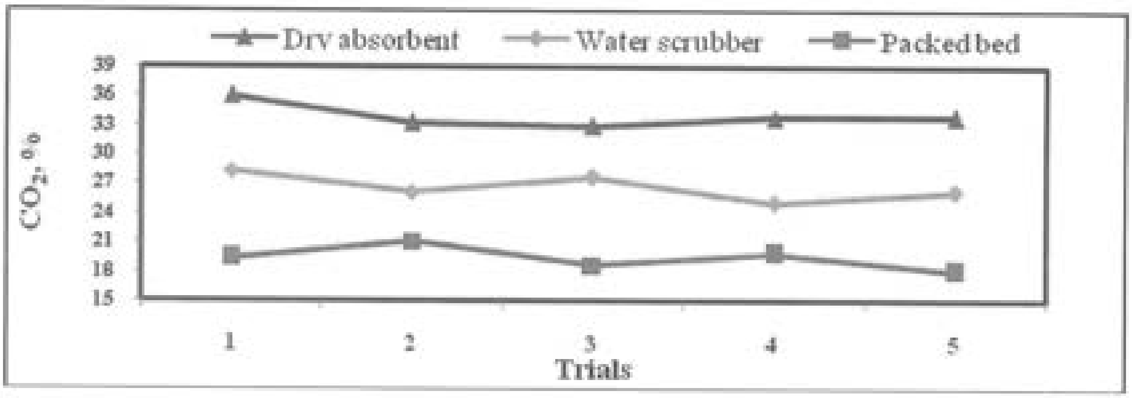


Fig. : Effect of three purification system on CO_2 percent

Conclusions

The concentrations of methane, carbon dioxide, hydrogen sulphide concentration and purification efficiency was found to be significantly different for various bed heights as well as flow rate. The biogas purification system was evaluated at bed height 15 cm, 20 cm, 25 cm and flow rate 1.2 m^3/h, 1.5 m^3/h, 1.8 m^3/h. Central composite quadratic model response-surface methodology by using Design Expert was used to optimize biogas purification system parameters for better CH_4percent, purification efficiency, lower CO_2 % and H_2S %, removal efficiency CO_2&H_2S. Bed height 20 cm and flow rate 1.5 m^3/h was found to favour the biogas purification, while a CH_4 65.56 %, CO_2 33.95 %, H_2S 212.45 ppm, and purification efficiency CH_4 16.96 %, removal efficiency CO_2 23.23 % and removal efficiency H_2S 88.02 % was observed.Two systems i.e. water spraying and packed bed water scrubber were developed. The water spraying system reduced the percent CO_2 upto 26.68 % and the packed bed water scrubber reduced the percent CO_2 upto 19.42 %.

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Green Fodder Production through Use of LEDs in Hydroponic Structure

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Abstract: The experiments were conducted on effect of Light Emitting Diodes (LEDs) on Fodder Production in Pipe Framed Hydroponic Structure at Instructional Farm, Department of Farm Structures, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during. The field experiments were laid out in factorial randomized block design with 19 treatments and 3 replications of each treatment for wheat and maize crop. The treatments consisted of two LED's reddish purple and white, three durations viz., 4 h, 8 h and 12 h and three LED intensity levels viz., 480 lux, 740 lux and 930 lux, respectively along with control treatment. Seeds of wheat and maize were sown in plastic trays with 350 g and 500 g seeds per tray, respectively. The irrigation was scheduled daily after 1 h for 1 min as automatic timer was connected with motor pump for irrigation.

The environmental parameters like temperature and relative humidity and biometric characteristics related to height of plant and fresh weight of tray and chlorophyll content and nutritive values viz., crude protein, fiber, fat, moisture content, dry matter and ash content of wheat and maize hydroponic fodder were studied. The reddish purple LEDs for 12 hours with light intensity of 930 lux during night time was found to enhance the plant growth in terms of plant height, fresh weight, chlorophyll content and nutritive value during green fodder production of wheat and maize in PDKV pipe framed hydroponic structure.

Keywords: LEDs, hydroponic structure, green fodder

Introduction

The word hydroponics has been derived from the Greek word 'water working'. Hydro means 'water' and ponic means 'working' and it is a technology of sprouting grains or growing plants without soil, but only with water or nutrient rich solution. However, hydroponic fodder can be well produced with the use of fresh water only and the use of nutrient rich solution is not obligatory. Fodder crops produced through hydroponics technology are also known as hydroponics fodder, sprouted fodder or sprouted grain. Sprouting of the grains is made inside a shade net house within a short period of approximately seven days.

Lighting is factor that affects the growth and development of plants. Because light is an important factor in building a food or photosynthesis of plants with chlorophyll this sensor uses energy to change carbon dioxide and water into carbohydrates and oxygen exposure other factors that affect the growth of plants, including wavelength, light intensity, duration of the light on the crop are features that affect the growth of plants (Luechai, 2015). The length of light waves at 430-460 nm and 630-660 nm estimated that due to the length of the light wave is ideal for the photosynthesis of plants and also help in the growth. The benefits of blue light (Wavelength 430-460 nm) is the light waves chlorophyll a, b can absorb more. Chlorophyll makes plants can stimulate the production of light even more. Extending photoperiod can produce more carbohydrate, increase growth, and stimulate the photosensitive pigments in lettuce for inducing relative gene expression and improved nutrient absorption for better quality (Gaudreau et al., 1994). The difference in light intensity and photoperiod, as each plant had its optimal light intensity and appropriate photoperiod for growth and development. LED had variable effects on different plant species (Li et al., 2012). LED light intensity and photoperiod effected on the leaf number, leaf length and leaf width (Morrow, 2008). The leaf number, leaf length and leaf width play an important role on photosynthesis and production. The fresh weight increased depending on the red:blue intervals (Shimokawa et al., 2014). Chlorophyll is an extremely important molecule in photosynthesis which allows plants to absorb energy from light and it would affect on the growth and development of plant.

Materials and Methods

Experimental site

The experiments were conducted at Instructional Farm, Department of Farm Structures, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the month of January 2019 to March 2019.

Hydroponic structure

The hydroponic structure developed at Department of Farm Structures was used for experiment purpose. Hydroponic structure was constructed using unplasticized polyvinyl chloride (U-PVC) pipes with external dimensions such as 3 m (height) x 2 m (width) x 3 m (length) and it consist of six internal rack structure with size of 0.45 m (height) x 0.45 m (width) x 0.8 m (length). The internal structure was equipped with 54 hydroponic trays with size of 0.45 m (length) × 0.30 m (width) × 0.15 m (height), which was equipped with semi-automated sprayer irrigation.

Hydroponic structure was covered with 50% ultraviolet (UV) stabilized shade net. In order to control the internal temperature of hydroponic structure, proper spraying of water was carried out at regular interval per day automatically to get a range of 25-30^{0}C temperature and 65-70% relative humidity (Gebremedhin, 2015).

Treatment details

The field experiments were laid out in factorial randomized block design with 19 treatments and 3 replications of each treatment with maize crop.

Factor A: Different colour of LEDs

C1 – White C2 – Reddish purple

Factor B: Duration of LED

D1 – 4 h D2 – 8 h

D3 – 12 h

Factor C: Intensity levels of LED

L1 – 480 lux (1 m LED) L2 – 740 lux (2 m LED)

L3 – 930 lux (3 m LED)

Experimental details

The treatment details of experiments are given in Table 1.

S.No.	Particulars	Specification
1	Name of the crop	Maize
2	Scientific name	Zea mays
3	Planting time	Winter season
4	Design	FRBD
5	No. of treatments	18
6	No. of replications	3

Environmental parameters

Temperature and Relative humidity

The temperature and relative humidity inside the hydroponic structure was recorded at an interval of 4 h (18:00 h, 22:00 h, 02:00 h and 06:00 h) and average was calculated for the period of 12 days for maize crop in hydroponic structure.

Biometric observations

In order to observe growth, yield and quality of maize following biometric observations were recorded.

Plant height

The plant height (cm) was measured by using measuring scale. The average plant height of each treatment was worked out.

Fresh weight

The fresh weight of green fodder from plot in every treatment was observed after harvesting. The total fresh weight of the fodder harvested from plot was recorded by fresh weight per tray and expressed in kg per tray.

Chlorophyll content

Chlorophyll content of maize was measured by chlorophyll meter before harvesting of crop. This meter gives the direct reading of chlorophyll content. The leaf from the top was taken for the measurement of chlorophyll content and expressed in mg/g.

Nutritive Values of Hydroponic Fodder

The nutritive values of hydroponic fodder in terms of Crude Proteins (%), Crude Fat (%), Crude Fiber (%), Moisture Content (%), Dry Matter (%) and Ash Content (%) were analyzed using standard procedures.

Results and Discussion

Environmental parameters

Temperature

The average temperature inside the structure was found to be slightly more using reddish purple LED followed by white LED and control treatment, this might due to be increase in wavelength of light.

Relative humidity

The average relative humidity of control treatment was found to be more than reddish purple and white LED treatment. This might be due increased temperature in LEDs treatment.

Biometric observations of hydroponic maize

The biometric observations on various growth characters like plant height and weight was taken and analyzed. The results are discussed below.

Plant height, fresh weight and chlorophyll content

The data obtained in respect to the plant height were statistically analyzed, tabulated and presented in Table 2.

Table 2 : Effect of LED colour, duration and intensity on plant height, fresh weight and chlorophyll content of maize

	Plant Height (cm)	Fresh Weight (kg)	Chlorophyll Content (mg/g)
A) Colour of LED			
C_1 – White	23.085	2.593	22.537
C_2 - Reddish purple	23.807	2.672	25.226
F Test	Sig	Sig	Sig
SE(m)	0.042	0.009	0.088
CD (P=0.05)	0.121	0.025	0.254
B) Duration of LED			
D_1- 4 h	22.611	2.541	22.394
D_2- 8 h	23.583	2.608	23.894
D_3- 12 h	24.144	2.749	25.356
F Test	Sig	Sig	Sig
SE(m)	0.051	0.011	0.108
CD (P=0.05)	0.148	0.031	0.311
C) Intensity Levels of LED			
L_1- 480 lux	22.256	2.381	21.611
L_2- 740 lux	23.394	2.674	24.028
L_3- 930 lux	24.689	2.843	26.006
F Test	Sig	Sig	Sig
SE(m)	0.051	0.011	0.108
CD (P=0.05)	0.148	0.031	0.311
Interaction Effect			
Colour X Duration (C X D)			
F Test	Sig	Sig	Sig

	Plant Height (cm)	Fresh Weight (kg)	Chlorophyll Content (mg/g)
SE(m)	0.073	0.015	0.153
CD (P=0.05)	0.209	0.044	0.439
Colour X Intensity (C X L)			
F Test	Sig	Sig	Sig
SE(m)	0.073	0.015	0.153
CD (P=0.05)	0.209	0.044	0.439
Duration X Intensity (D X L)			
F Test	Sig	Sig	Sig
SE(m)	0.089	0.019	0.187
CD (P=0.05)	0.256	0.054	0.538
C X D X L			
F Test	Sig	Sig	Sig
SE(m)	0.126	0.026	0.265
CD (P=0.05)	0.362	0.076	0.761
Control	20.767	2.190	17.800
F Test	Sig	Sig	Sig
SE(m)	0.153	0.044	0.346
CD (P=0.05)	0.886	0.289	1.448
CV	0.940	1.706	2.214

Effect of colour of LEDs, duration and light intensity

Data presented in Table 2 indicated the significant difference in plant height, fresh weight and chlorophyll content of maize using different colour LEDs, duration and light intensity.

Plant height of 23.80 cm was found to be significantly higher under reddish purple LED treatment followed by plant height of 23.08 cm under white LED treatment and 20.76 cm under control treatment. The plant height was found to be increased significantly with increased durations of LEDs. It revealed that plant height was found to be increased significantly with increased intensity levels of LEDs.

Fresh weight (2.67 kg) was found to be significantly higher under reddish purple LED followed by white LED (2.59 kg) and control treatment (2.19 kg). It revealed that fresh weight was found to be increased significantly with increased durations of LEDs. It was observed that 12 h duration of LED was found to have significantly more fresh weight (2.74 kg) than 8 h duration (2.60 kg) and 4 h duration (2.54 kg) of LEDs. Extending photoperiod produced more carbohydrate, increased growth of wheat and produced more fresh weight. It revealed that fresh weight was found to be increased significantly with increased intensity levels LEDs. It was observed that when maize was produced under high intensity LEDs of 930 lux (2.84 kg), it gave better result than the maize produced under 740 lux (2.67 kg) and 480 lux (2.38 kg) of LEDs. It was found that, the light intensity affected the growth of maize.

Chlorophyll content (25.22 mg/g) was found to be significantly higher under reddish purple LED followed by white LED (22.53 mg/g) and control treatment (17.80 mg/g). It revealed that chlorophyll content was found to be increased significantly with increased durations of LEDs. The 12 h duration of LED was found to have significantly high chlorophyll content (25.35 mg/g) followed by 8 h duration (23.89 mg/g) and 4 h duration (22.39 mg/g) of LEDs. It revealed that chlorophyll content was found to be increased significantly with increased intensity levels of LEDs. It was observed that when maize was produced under high intensity LEDs of 930 lux (26.00 mg/g), it gave better result than the maize produced under 740 lux (24.02 mg/g) and 480 lux (21.61 mg/g) of LEDs. This might be due to intensity of light affected on chlorophyll absorption by plant.

Interaction effect

From the data presented in Table 2, it was observed that interaction effects between LED colour, duration and intensity levels in respect of plant height and chlorophyll content were found to be significant and in respect of fresh weight was non-significantly influenced.

Nutritional compostion of hydroponic maize

Crude protein, crude fiber and crude fat

The data obtained in respect to the crude protein were statistically analyzed, tabulated and presented in Table 3.

Table 3 : Effect of LED colour, duration and intensity on crude protein, crude fiber and crude fat of maize

S. N.	Particulars	Specifications	
		Control Treat.	LED Treat.
1	Chlorophyll Content (mg/g)	17.80	26.00
2	Crude Proteins (%)	12.73	16.51
3	Crude Fiber (%)	14.10	15.21
4	Crude Fat (%)	1.90	2.54
5	Moisture Content (%)	83.13	81.27
6	Dry Matter (g)	431.73	478.11
7	Ash Content (%)	2.12	2.54

Data presented in Table 3 indicated the significant difference in crude protein, crude fiber, crude fat, dry matter and ash content of maize using different colour LEDs.

Conclusion

The reddish purple LEDs for 12 hours with light intensity of 930 lux during night time was found to enhance the plant growth in terms of plant height, fresh weight, chlorophyll content and nutritive value during green fodder production of maize in PDKV pipe framed hydroponic structure.

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Study on Gasifier

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1. Introduction

The word gasification (or thermal gasification) implies converting solid fuel into gaseous fuel by thermo-chemical model, without leaving any solid carbonaceous residue. Actually, biomass gasification means incomplete combustion of biomass resulting in production of combustible gases, consisting of Carbon monoxide (CO), Hydrogen (H2) and traces of Methane (CH4). The mixture is called producer gas. Producer gas can be used to run internal combustion engine (both CI and SI) can be used as a substitute to furnace oil in direct heat applications and can be used to produce, in an economically viable way, methanol-an extremely attractive chemical which is useful for heat engines as well as chemical feed for industries.

2. Historical Backgroud

The process of gasification to produce combustible from organic feed, was used in blast furnace over 180 years age. During the World War-II, biomass gasification systems appeared all over the world for heating and power generation. After the World War-II, the lack of strategic impetus and the availability of cheap fossil fuels lead to general decline in the producer gas industry.

3. Theory of Gasification

1.1. Introduction

The production of producer gas (generator gas) is known as Gasification, is in complete (partial) combustion of solid fuel (biomass) and takes place at temperature of about 1000 C. The reactor in which combustion takes place is called Gasifier.

Thecombustion products from complete combustion of biogas generally consists of carbon dioxide (CO2). Water vapour (H2O (g)), oxides of nitrogen (NOx) and oxides of sulphur (SOx) . However, in gasification, where there is a surplus of solid fuel (partial combustion) the product of ore combustible gases like carbon monoxide (CO), Hydrogen (H2) and trace of methane and non useful products like tar and dust. The production of these gases by reaction of water vapour and carbon dioxide through a glowing layer of charcoal. So, Gasifier design must create following condition:

(i) Biomass is reduced to charcoal and

(ii) Charcoal at suitable temperature is converted to produce mixture of carbon Monoxide (CO) and hydrogen (H_2).

1.2. Steps involved in the Gasification

The main steps involved in the gasification can be categorized as upstream processing, gasification and downstream processing, processes involved in biomass gasification is given below:

Processing of biomass -> Gasification -> Gas cleanup and reforming -> Gas utilization

The following table 1. Show that carried out in different steps a

Table 1. different steps involved in the Gasification

Upstreams	Processing	Gasification	Downstream Processing
Size reduction Drying Preparation of gasification agents	Heating Chemical reaction catalysis	cleaning of tar from syngas Reforming of the syngas	Gas forbing Gas berner Fuel cell,combined and power

4. Terminology

4.1. Gasification Process

Gasification is a thermochemical process in which biomass is subjected to a high temperature (about 1000^{0}C) and depending upon the quantity of oxygen supplied pyrolysis and gasification of biomass occur.

4.2. Gasifier (Generator)

A reactor, which converts solid fuels in to gaseous fuel through thermo-chemical process.

4.3. Producer gas

It is mixture of combustible gases (like CO,H2 and CH4) and non-combustible gas (N2) produced when materials like wood, charcoal, coke, slack, lignite or crop residue are burnt in the presence of insufficient air of excess of biomass.

4.4. Pyrolysis

It is the process, in which, the heat uses to breakdown biomass and yields charcoal, wood-oils, tars, and gases. It is the first step in the combustion and pyrolysis of biomass and takes place between 280 to 500^{0}C.

Note: Up to the temp. of 200^{0}C only water is driven off.

4.5. Pyrolysis Zone

In this zone, the solid material starts breaking at 250 ^{0}C producing car as well as condensable and non-condersable gases. All the pyrolysis move to the oxidation zone.

4.6. Combustion/Oxidation Zone

In this zone, oxygen (air) is introduced. A very important function of oxidation zone apart from the heat generation is to convert and oxidiseall the condensable organic products from the pyrolysis zone. The combustion is exothermic and yields a theoretical oxidation temperature of 1400 ^{0}C.

4.7. Reduction Zone

In this zone, the sensible heat of the gases and charcoal is absorbed in the endothermic reactions between water, CO2 and carbon in the charcoal. Consequntly, the temperature of reduction zone are normally less than oxidation zone (800-1000^{0}C).

4.8. Equivalence Ratio (ER)

The equivalence ratio is defined as the ratio of actual air, used in a reaction to stoichiometric air requirement for the reaction.

4.9. Turn Down Ratio (TDR)

Turn down ratio of a gasifier is the ratio of maximum to minimum gas generation rates, at which, it can be reasonably efficiently operated without drop in quality of gas.

4.10. Gasification Efficiency

It is the percentage energy of biomass converted in to a cold producer gas (free from tar). It is expressed as follows:

$$\eta_g = \frac{\text{Calorific Value of Produce gas X Total gas produce from 1kg of biomass}}{\text{Average Calorific Value of Biomass (per kg)}} \tag{4.1}$$

4.11. Specific gasification rate

Specific gasification rate is the quantity of biomass consumed per unit time and cross-sectional area of gasifier. SGR may be calculated by following relation.

$$\text{SGR} = \frac{\text{Weight of dry biomass ueed per unit time } (kgh^{-1})}{\text{Cross-sectional area of the reactor } (m^2)} \tag{4.2}$$

4.12. Specific Solid Flow Rate

It is defined as the mass flow of fuel measure at the throate. It is expressed as

$$S_{GR} = \frac{S_{GR}}{V} \tag{4.3}$$

Where, V = Volume of gas obtained by unit mass of biomass (Take the unit of V from the unit of SGR)

4.13. Gas Reduction Time

It is the average time by the gas phase in reaction zone. It is expressed as

$$G_{RT} = \frac{V\,X\,E}{G}\,X\,\frac{273}{T}\,X\,360\,;s \tag{4.4}$$

where,

E = vaid fraction = $\frac{Volume\ of\ voides\ in\ bed}{Totol\ volume\ of\ reactor}$

G = Gas flow rate

T = Absolutetemperature, K

4.14. Comparison between pyrolysis and Gasification

It is given in Table 2

Table 2 : Comparison between pyrolysis and gasification

S.NO.	Particlers	Pyrolysis	Gasification
(I)	Operation Operating	Distructive distillation i.e., in absence of air	In the percence of partial supply of air
(II)	Temperature	Lower (up to 350^0 C)	Higher (750-950^0C)
(III)	State of Products	Solid ,liquid and gases	Only gases
(IV)	Chief constituent	CO and H_2	CO and N_2
(V)	Power generation capacity	Low	High
(VI)	Thermal efficiency	Lower	Higher
(VII)	products	CO,$CO_2$$CH_4$,$C_2H_6$and H_2	CO,CH_4 ,CO_2,H_2,N_2 heavier hydrocarbons and water vapour

5. Thermochemical Reaction in Gasification

The major reactions occurring in gasification process are as follows:

Sl.no	Chemical Synthesis	Reaction	Thermodynamic sate
a)	Heterogeneous water gas shift reaction (Exothermic)	$C + H_2O = H_2 + CO$	$\Delta H = +118.5$ kJ /mol
b)	Shift conversion (Endothermic)	$CO + H_2O = H_2 + CO2$	$\Delta H = -42.3$ kJ / mol
c)	Methanation (Endothermic)	$CO+3H_2 = CH_4 + H2O$	$\Delta H = -206.0$ kJ /mol
d)	Hydrogenating gasification (Endothermic)	$C + 2H_2 = CH_4$	$\Delta H = -87.5$ kJ /mol
e)	Partial oxidation (Endothermic)	$C + ½O_2 = CO$	$\Delta H = -123.1$ kJ/ mol
f)	Oxidation (Endothermic)	$C + O_2 = CO_2$	$\Delta H = -406.0$ kJ /mol
g)	Boudouard reaction(Exothermic)	$C + CO_2 = 2CO$	$\Delta H = +159.9$ kJ/ mol

4.6 Composition of Producer Gas

A typical co position of the producer gas generated from wood and other biomass gasification is presented in table 1.3.

Table 1.3 : Gas composition of various biomass materials on gasification

Sr. No.	Gases	Wood (% by vol)	Corn cobs (% by vol)	Barley straw (% by vol.)	Tree pruning (% by vol.)	Rice Straw (% by vol.)	Peat (% by vol.)
1.	CO_2	09.70	10.20	10.90	13.70	08.40	15.30
2.	CO	23.90	21.70	20.90	18.80	26.10	16.15
3.	H_2	16.30	16.90	13.40	16.40	12.40	12.30
4.	O_2	-	-	-	-		-
5.	CH_4	08.17	04.46	04.94	04.75	07.79	00.75
6.	C_2H_6	00.43	00.23	00.26	00.25	00.41	-

Source: Kaupp 1984a

4.7. CLASSIFICATION OF GASIFIER

Since there is an interaction of air or oxygen and biomass in the gasifier. On the basis of air or oxygen introduced in it. Gasifiers are broadly classified into

(i) Downdraft type
(ii) Undraft type
(iii) Cross draft type and
(iv) Fluidized-bed types

4.7.1. Up-draft gasifier

An Up-draft gasifier is characterized of a counter,current flow of the fuel and air or gas in the reactor. So,it is also called counterflow gasifier. Fuel is fed from thetop and air is introduced at the bottom of the reactor.The producer gas exits from the top of the gasifier.Oxidation zone is formed at the bottom of the gasifier.The reduction, pyrolysis and drying zones are formedabove the oxidation zone insequence. The gas produced,has practically, no ash, but contains tar and water vapourbecause of passing of gas through unburent fuel. Thereaction zones in an up-draft gasifier are shown Fig. 4.1

This type of gasifier is easy to build and operate. Thefollowingare the main advantages of an up-draft gasifier.

(i) Small pressure drop
(ii) Good thermal efficiency
(iii) Little tendency to slag formation.
(iv) Easy to construct
(v) Easy to operate

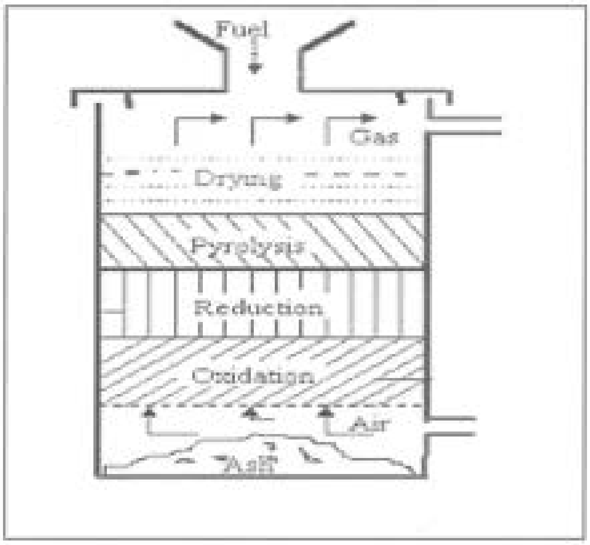


Fig 4.1 : Reaction Zone in an updraft gasifier

4.7.2. Down-draft gasifier

Down-draft gasifiers are characterised by co-current flow of air or gas and the fuel. So it is also called co-current flow gasifier. In this gasifier, air entera the fire zone. Fuel and air or gas move in the same direction and exist near the bottom of the generator. In a down draft gasifier, the pyrolysis products, (i.e. tar and other condensable components) pass through high temperature oxidation and reduction zones, before the gas exits from the gasifire as shown in Fig. 4.2 resulting in tars are degraded or cracked to methane and steam reacts to produce water gas. Down-draft gasifiers can be further classified as:

(i) Down-draft gasifier with throat: This gasifierhas a narrow section below the air entrance point in the reactor, which is calledthroat. Due to decrease in the cross-sectional area at the throat, the air or gas velocity increases resulting high and better temperature distribution in a down-draft gasifier are shown in Fig. 8.2.

(ii) Down-draft gasifier without throat: Down-draft Gasifier with throat produces best qualityproducer gas,but it is not suitable for gasification of agro-residue likepaddy husk, groundnut shell, etc. Since paddy husk is an important agricultural crop residue having potential as an energy source, a down draft without throat gasifier wasconceived for the gasification of paddy husk. The reactionzones sequence in this gasifier is similar to that of thedown-draftgasifire with throat. The cold gas efficiency of this gasifier varies from 55% to 65%, depending uponthe operating conditions. The following are the mainadvantages of down-draft gasifier:

(i) Flexible adaption of gas production to load.

(ii) Low sensitivity to charcoal dust and tar content of fuel.

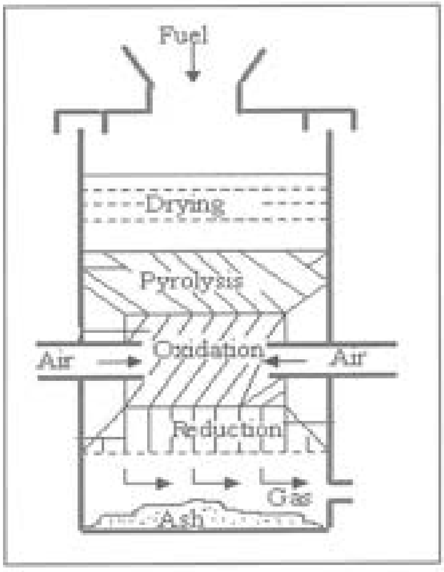


Fig 4.2 : Reaction Zone in an downdraft gasifier

4.7.3. Cross-draft gasifier

Schematic diagram of a cross draft gasifier is showninFig. 4.3. Air enters the gasifier through a water-cooled nozzle, mounted on one side of the fire box. This gasifiercan operate with wide variety of fuels compared to an up-draft or a down-draft gasifier. High gas exit temperature,higher gas velocity at the gas exit and poor carbon dioxidereduction are certain characteristics of this type of gasifier,due to which, they have low efficiency. This type of gasifierhas been used for gasification of coal earlier.

The following are the main advantages of cross-draft gasifier:

(i) Short design height

(ii) Very fast response to load.

(iii) Flexible gas production.

Note: The gases travel horizontally through the hot coals and exist through the opposite side of the generator

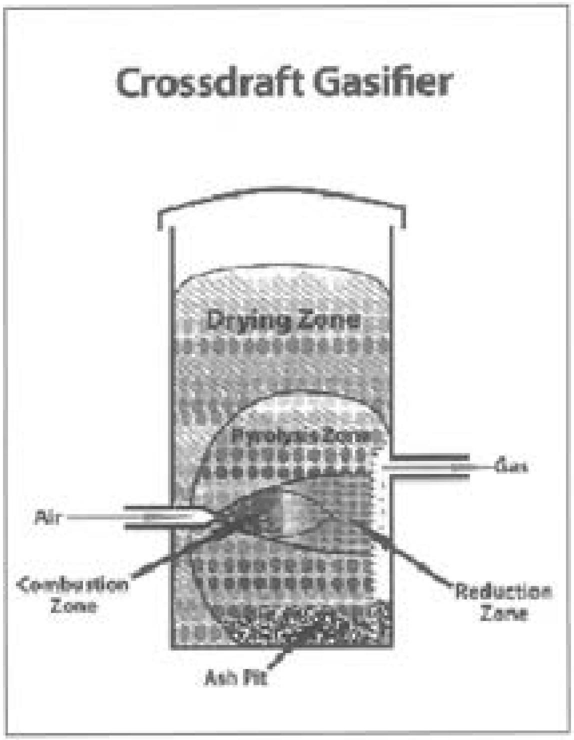
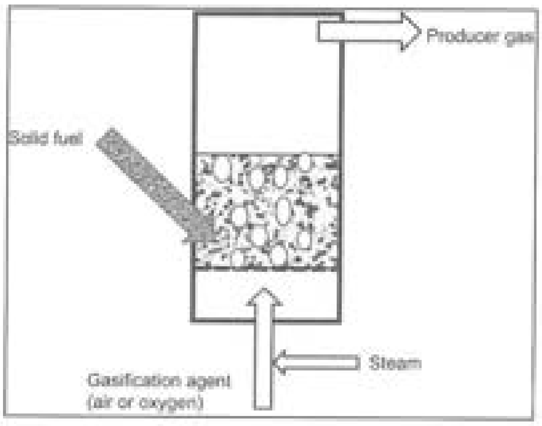


Fig 4.3 Reaction Zone in an cross draft gasifier

4.7.4. Fluidized Bed Gasifier

Fluidized bed gasifier is used for those fuels(biomas) which have high ash content and the ashhas low melting point. Fluidized bed gasifier is ahomogeneous reactor bedof some inert sandmaterial as shown in Fig. 4.4. The fuel is introduced in the inert bed material and air is blown upwardsthrough the biomass bed. Oxidation, reduction,pyrolysis and drying takes place simultaneously.This gasifier is characterized by high gas exist Temperature, very high solid particulate matter inthegas and relatively low efficiency. The major advantage of fluidized bed gasifier over, say,downdraft is its flexibility with regard to feed rateand its composition. Fluidized bed systems can also have high volumetric efficiency and temperature can be easly controlled.



Notes: (i) Diesel engine can't run completely on producer gas thus to produces 1 kWh of energy they consume 1kg of biomass and 0.07 lit. of diesel : (ideal fluied)

(ii) The agro residuse in general has 20 to 30% ash after gasification.

(iii) The space occupied by ash in the range of 10 to 20% of volume of fed biomass.

(iv) The density of ash is 50 to 100 kg/m3

8. Cooling and Cleaning of Producer Gas

The combustible gases from the gasifier have impurities like char particles, ash, tar, dust and oil. In order for the gas to be used in internal combustion engines, for direct heat applications and feed stock for production of chemicals like methanol, it should be cleaned of from above impurities and be cooled. Thus, cooling and cleaning of gas plays a vital role in the success of producer units.

4.8.1. Cooling of Gas

The temperature of gas coming out from gasifier is normally beween 300-500 ^{0}C. This gas has to be cooled In order to raise its calorific value. Various types of cooling equipment have been used to achieve purified gas. Most coolers are gas exchangerswhre the cooling is done by free convection of air on the outside surface of heat exchanger. Since the gas also contains moisture and tar, some heat exchangers provide scrubbing of gas. Thus ideally the gas going to an internal combustion engine should be cooled to nearly ambient temperature.

4.8.2. Cleaning of Gas

Cleaning of the gas is difficult and is very critical. Normally, dry, moist and wet filters are used for cleaning.

9. Comparision Among Updraft, Downdraft and Crossdraft Type Gasifiers

It is given in Table 4.3

Table 4.3 : Comparison among gasifiers

S.No	Particulars	Updraft	Downdraft	Cross draft
(i)	Pressure drop	Small	Large	Medium
(ii)	Sensitivity of tar and moisture content of fuel	Greatly	Large	Medium
(iii)	Sensitivity to slag formation	Little	Low	High
(iv)	Efficiency	Highest	Medium	Low
(v)	Situation of Oxidation and Reduction zone from the top gasifiers	Oxidation zone below the reduction zone.	Oxidation zone above the reduction zone	Oxidation and Reduction Zone are near the air nozzle
(vi)	Entering of the air	Below the fire zone	Above the fire zone	One side of fix zone

10. Factors Affecting the Performance of Gasifier

Gasifiers is very fuel specific and it is tallored around a fuel rather than the other way round, The following parameter of the fuel (material/biomass) affect the performance of a gasifier.

(i) Energy content and bulk density of the material
(ii) Moisture content
(iii) Ash and slagging characteristics
(iv) Tar content
(v) Equivalent Ratio

4.10.1. Energy Content ad Bulk Density of the Material

The density of material plays a vital role, while considering energy content of feeds on volumetric basis, and in transporting, handling and sizing of the reactor vessel. Experiments revealed that the higher the energy content and bulk density of material, the similar is the gasifier volume since for one charge one can get power for longer time. The average heating value of material should be more than 10 MJ kg -1.

4.10.2. Moisture Conten

The presence of moisture is essential for gasification reaction, but when it is present in excess it has detriment effects on the performance of gasifier. It is desirable to use material with low moisture content (about 8-15%) because the presence of high moisture content requires large quantity heat for evaporation of this moisture resulting in lowers the combustion efficiency and creates problem. Besides impairing, the gasifier heat budget, high moisture content also put load on cooling and filtering equipment by increasing the pressure drop across these units because of condensing liquid.

4.10.3. Ash and Slagging Characteristics

The mineral content in the fuel that remains in oxidized form after complete combustion, is usually called ash, Silica (SiO2), calcium oxide (CaO), Ferric oxide (Fe2 O3), ferrous oxide (FeO) and magnesium oxide (MgO) are common examples of ash.

4.10.4. Tar Content

Tar is one of the most unpleasant constituents of the gas, as it tends to deposit in the carburetor and in take valves, causing sticking and trouble in some operations. It is a product of highly irreversible process taking place in the pyrolysis zone. The physical of tar depends upon temperature and heat rate and the appearance ranges from brown and watery to black and highly viscus.

4.10.5. Equivalence Ratio

Equivalence ratio is the ratio of actual air used in combustion to stoichiometric air requirement for the combustion. The better is the equivalence ration the better is the performance of the gasifier.

11. Advantages of Gasification

The following are the main advantages of gasifition :

(i) Gasification offer shigh flexibility in term of various bio-mass material as the Feed stock.

(ii) Gasification has thermo-chemical conversion efficiencies in the range of 70 to 90 percent.

(iii) The area requirement for gasification equipment is the least per unit output of energy in the form of heat and electricity.

(iv) The gasification equipment has high'urn down ration comparable to bio-gas.

(v) Gasification outputs are suitable as a fuel to all types of internal combustion engine.Problems in Development of Gasifier.

12. Recommended Fuel Size

It is given Table 4.4.

Table 4.4 : Recommended fuel size for small gas producers

S.No	Type of gassifier	Recommended fuel	Size of fuel, mm
1.	Downdraft gasifire (Malbay)	Anthracite	10-25
2.	Downdraft gasifies (Wisco)low temperature coke	Charcoal ,Peat coke 15	20-40
3.	Downdraft gasifire(GohinPoulence)	Charcoal	
4.	Downdraft gasifire (Brandt)	Anthracite	15-22
5.	Up draft (koela)	Wood	05-15
		Charcoal	80X 40 X 40
		Low Temperature coke Anthrscite	10-20
6.	Downdraft gasifire (USA)	Wood	10-15
		Corn stalk & cereal straw	05-10
		Rice husk	20-40 cubes
		Corn cob	30X 30X 50
		Fruit pits	Large 10
			40
7.	Downdraft gasifire (Imbert)	Wood	15-30
		Oak	
			60-80
8.	Downdraft gasifier(DSwedish)	split firewood thick blocks	20X 40X 60
		Spilt firewood thin block	
		Cylinders	80X 250
		Charcoal coarse grade	60X 200
		Charcoal Fine grade	
		Fine grade Wood.	
		Coarse grade wood	85,25-75,l/d
9.	Downdraft gasifire (UK)	Fine grade wood	10-60
10.	Downdraft gasifire (R&D Organizations)	Coarse grade wood	10-30
11.	Downdraft gasifire (PAU)		20-50,l
			30-80,l
12.	Downdraft gasifire (IISc.Bangalore)	wood chips & Agro residues	
13.	Downdraft gasifire (IIT Bombay)		15-25,d
14.	Downdraft gasifire (CIAE)	Wood chips	
15.	Downdraft gasifier (SPRERI)	Wood chips	35,25,l/d
	Downdraft gasifire(Ankur)	Soyabean straw	35,25,l/d
		Rice husk	50,25,l/d
		Crop residues	50,25,l/d
			50,25,l/d
			50,25 ,l/d

Source: Kaupp 1984 L= Length, d= Diameter

13. Design of Gasifier

4.13.1. Capacity of gasifier

The first step in the design of gasifier is to identify the application and size/capacity of the gasifier in terms of the gas requirement and the type and quantity of fuel to be gasified.

Components of the gasifier

The main components of the gasifier are:

(i) Grate
(ii) Throat
(ii) Air nozzle/air distribution system
(iv) Ash removal systems, ash removal part
(v) Gas outlet
(vi) Ignition port
(vii) Biomass feeding port
(viii) Hopper

4.13.2. Design of downdraft gasifier(without throat)

There are following steps for calculating different parameters of throatless gasifier.

(i) Fuel consumption, = W_1- W_2 (4.5)

Where,

W_1 = Weight of biomass before operation

W_2 = Weight of biomass after operation

q = Fuel consumption,kg/h

p = Engine outlet ,kW

η_{ox} = Overall efficiency, i.e. (Gasification efficiency X Engine combustion efficiency)

H_w = Lower heating value of biomass,kj/kg

(ii) Quantity of gas produced, $Q = \frac{\eta g X\ q\ Xw}{Hg}$.,$m^3h^{-1}$ (4.6)

Where,

ηg = Gasification efficiency

q = Fuel consumption,kg/h

H_w and Hg = Lower calorific values of biomass producer gas in kJ/kg and kJ/m^3

(iii) Volume of Reactor, $V = \frac{tXq}{Sp}$.,m^3 (4.7)

Where,

t = Time of operation .,

S_p = pled density of biomass ,kg/m^3

(iv) Area required

A = (fuel consumption/specific gasification rate)

Diameter of the reactor, $\sqrt{\frac{A}{\pi D2}}$., m (4.8)

(v) Height of the reactor, $h = \frac{VX\ 4}{\pi\ D2}$., m (4.9)

4.13.3. Design of Updraft gasifier

The design of a gasifier depends mainly upon the fuel to be gasified. High efficiency, tar-free gas and excellent hearth-load are desirable properties of gasifier that contradict each other, thermodynamically and cannot be simultaneously optiised. Important points in the design of an updraft gasifier are:

(i) Size and type of the grate
(ii) Location and diameter of gas outlet
(iii) Method of air distribution system
(iv) Ash removal system
(v) Hopper size and shape

Ignition port, fuel feeding, ash removal port/duct are common to all types of gasifier.

4.13.4 Grate

The grate design is also very important for the efficient functioning of the gasifier because it performs the several functions. The grate separates the ash bin from the partial combustion zone and supports the entire fuel column. The grate design must allow for the ash to move freely through it into the ash-bin and at the same time, prevent carbonized fuel falling through it. Another important point in the design and operation is, the protection layer of ash, that should be maintained above the grate. Too thick ash layer, seriously interfere with the operation due to increase in pressure drop from the gasifier and hence, lower gasification rate. The average gasification rates of biomass considered for design of grate are given in Table 4.5

Table 4.5 : Average gasifier rate of biomass

Sr.No	Type of throat	Average capacity (SGR),kg/h-m^2
(i)	No-throat-design	100-275
(ii)	Single throat	200-1200
(iii)	Double throat	600-4200

Parameters, which influence the grate design, are:

(i) Rate of ash removal
(ii) Superficial gas velocity and flow field
(iii) Size distribution of the char
(iv) Bulk density of the char
(v) Construction and cost maintenance

The area of grate may be calculated by the following formula:

$$A = \frac{q}{SGR} \tag{4.10}$$

Where, A= grate area, m^2 q= biomass consumption, kg/h

SGR = specific gasification rate of biomass, kh/m^{-2}

The diameter of grate.,

$$D = \frac{\sqrt{4A}}{\pi} \tag{4.11}$$

4.13. Location of Gas outlet

The updraft gasifier draws off the gases just above the reduction zone. The drawing off the gas above the reduction zone has the beneficial effect of obtaining a more tar free gas but results in high exit temperature and decreased overall efficiency. The other point, which is to be considered for the location of gas outlet, is the space between the top of the fuel column and gas exit. The large capacity gasifier provides a free space of fuel below the gas exit that allows the gas to expand, cool down and decreased its velocity before it reaches the outlet pipe. The low velocity results into the coarse fuel particles entered in the gas current are allowed to settle down and do not reach the gas exit.

Assumptions that allow an exactrepresentation of terminal velocity of a particle are :

(i) The particle is spherical and rigid and no slip exits and no slip between the particle and the gas.
(ii) The gas is homogeneous within the length scale of the particle
(iii) The settling velocity is so low that all inertia effects are negligible.
(iv) The flow field is laminar.

4.13.6. Ash Removal Systems

The following ash removal options are available:

(a) Fixed grate allowing for periodic removal of the ash.
(b) Mechanical, rotating grate allowing for periodic removal of the ash.
(c) Mechanical, rotating grate allowing for continuous ash removal.

Note:	The agro residues in general have 20 to 30 percent residues (Ash) after gasification. The space occupies by the ash is in the range of 10 to 25 per cent of volume of the fuel. The density of ash had 50 to 100 kg/m3.

14. Operating Parameters of The Gassifir

The following are the main operating parameter of the gassifier which influences the quality and conversion efficiency:

(i) Biomass and it's property

(ii) Flow rate of biomass

(iii) Oxidizing agent or air flow rate or equivalence ratio (ER) or super facial velocity (SV)

(iv) Gasification temperature

(v) Type and design of gasifies

(vi) Type and amount of catalyst

(vii) Steam flow rate

4.14.1. Biomass and their properties

It includes parameters:

(a) Moisture Content (MC): Moisture is essential for and its optimum value is about 9 to 15%. If the value of MC is very high then heat for evaporation is required very high, influences the quality and as well as efficiency of gassifier.

Note: The high MC lowers the combustion efficiency creates problem in flow of gassifier.

(b) Dust content: All gasifies fuels produced dust. This dust is harmful Since it can clog the internal combustion engine and hence to be remove. The gassifier design should be such that it cannot produce more than 2 to 6 g/m3 of dust.

(c) Tar content: Tar is one of the most unpleasant (undesirable) constituent of gas as it tends to depositein the carburatior and in takevalves causing sticking and trouble some operation. it is a product of highly irreversible process taking place in the pyrolysis zone. A welldesign gassifier should put out less then 1 g/m3 of tar. In this case generally down draft (D/D) gassifier is selected for gasification.

(d) Energy content and bulk density of fuel: The higher the energy content and bulk density of biomass the smaller is the gasification volume. Since for one charge one can get power for longer time.

The biomass which has higher bulk density is easily to transporting, handling and sizing. The basic feed characteristic is more easily judge from angle of repose. Good feed Hooperdesign for a cone angle i.e. doubles the angle of repose.

Note: With an angle of repose over 45 the feed may not flow even in a straight cylinder and will require some agitater.

(e) Ash content: The ash fusion temperature should be more then 1150^{0}C The biomass with high ash content require greater attention to grate (Chula) design. Gas disengagent and positive char-ash Fitted.

(a) Slagging: Slag is formed due to fusion of ash and process is called slagging. Slagging is over come by two types of operation in gassifirers:

(i) Low temperature operation that keeps the temperature well below the fusion temperature ofthe ash.

(ii) High temperature operation that keeps the temperature above the melting point of ash.

The 1st method is usually accomplished by steam or water injection while the later method requires provision for tapping the molten slag out of the oxidation zone. Each method has its advantage and disadvantages and depends upon specific fuel and gasifier design.

4.14. Flow Rate of Biomass

Over feeding of biomass can lead to plugging and reduced conversions efficiency whereas starve feeding results in less gas yield. Therefore an optimum biomass flow rate is desired for the gasification system to maximize energy efficiency.

Note: Optimum biomass flow rete depends primarily on the design of gasifier and as well as properties of biomass.

4.14.3. Oxidizing Agent or Air Flow Rate

ER and SV are the measures of air flow rate. ER is the ratio of air flow to the air flow required for the stoichiometric combustion of the biomass, which indicates extent of partial combustion. The SV is the ratio of air flow to the cross-sectional area of the gasifier.

Which removes the influence of gassifier dimension by normalization, therefor both ER and SV are directly proportional to the air flow. Air flow influences the gasification products in different ways. Air (O2) supplies for combustion (and fluidization in case of fluidizedbed) effect the residence time. By varying the amount of O2 supply air flow rate controls the degree of combustion, which in turn, affects the gasification temperature. Higher air flow rate results in higher temperature which leads to higher biomass conversion and higher quality of fuel (producer gas), but an excess degree of combustion on the other hand results in decrease energy content of the gas produced because a apart of combustion energy is spent during combustion. Higher air flow also shorten the residence time, which may decrease the extant of biomass conversion.

4.14.4. Gassification Temperature

Gasification Temperature plays a vital role to affect the product gas like composition or constituent and properties. High temperature results increase gas yield because of higher conversion efficiency.

At a temperature above 750 to 800 C, the endothermic nature of the H2 production, reactions (Steam reforming and water gas reaction), results is an increase of H2 content and decrease in CH4 content with an increase in temperature. Since water gas shifting reaction, steam reforming reaction, water gas reaction and bounded reaction occurs simultaneously, the content and ratio H2, CO, CO2, CH4 in the product gas are affected by the temperature and partial pressure of the reactant.

4.14.5. Steam Flow Rate

Supply steam as gasifingagent increases the partial pressure of water inside the gassification chamber, which favour the water gas shift and methane reaction leading to increase H2 production.

Howerver, the gasification temperature needs to be high enough than 750 to 800 C for the steam reforming and water-gas reaction to be favorable. Catalyst can lower the operating temperature needed for the above reaction occurs.

Note: Higher steam to biomass ratio also leads to higher bio-mass conversion efficiency as well as reduction in tar.

Maintenance of gasifier:

(i) Gas outlet, pipes and valve should be checked regularly to find potential leakage. insulation of generator, pipe and other component should be changed and maintain annually.

(ii) Slag removal checking and replacement of all heating devices should be done frequently.

(iii) Grate should be checked regularly and remove ash frequently.

(iv) Before using gasifier, it should be properly inspected that all its parts properly cleaned. It does not good to use gasiifire without in proper condition.

(v) Emptying and then checking and repairing the gasifier.

Example 4.1. Design a gasifier plant for a farmer having abundant amount of maize stalks for 10 kW diesel pumpset for 6hrs. a day. Assume piled density, lower value and lower calorific value of producer gas are 50 kg/m3m and 5.5 MJ/m3 respectively. Overall efficiency = 15% and gasification efficiency = 65%.

Solution:

(i) Fuel consumption or Feed Rate

$$q = \frac{3600 \text{ X P}}{\eta \text{ 0aX Hw}}$$

Where, p = Engine output = 10 KW,

η_{oa} = Overall efficiency = 15 % = 0.15 $\frac{\text{ng X q X HW}}{\text{Hg}}$

H_w = Lower heating valueof biomass

= 16 MJ/kg = 16X 10^3KJ/Kg

$$q = \frac{3600 \text{ X } 10}{\text{Hg}}$$

Where, η_g = Gasification efficiency = 0.65

q = Fuel consumption ,kg/h.

Hg = Lower calorific value of producer gas (kj/m^3)

= 5.5 MJ/m^3=5.5 X 10^3kJ/m^3

$$Q = \frac{3600 X 10}{0.15 X 10 X 10^3} = 15 \text{ kg/h.}$$

$$= \frac{0.65 \times 15 \times 16 \times 103}{5.5X\ 103} = 28.36 \text{ M}^3\text{/h}$$

(iii) Volume of rector

$$V = \frac{t.q}{Sp} = \frac{6 X 15}{50} = = 1.8 \text{ m}^3$$

where, t = Time of operation

Sp = Piled density ofv biomass,kg/m^3

For Safety,10% extra volume is added, so, total reactor volume is added ,

So total reactor volume = $1.8 + \frac{10}{100} X\ 1.8$ = 1.8 + 0.18= 1.98m3

(iv) Area Required,

$$A = \frac{q}{SGR}$$

Where, SGR = Specific Gasification Rate

Let us assume SGR=150 kg$h^{-1}$$m^{-2}$

Diameter of reactor,d = $\sqrt{\frac{4A}{\pi}}\ \sqrt{\frac{4X\ 0.1}{3.14}}$ = 0.201 m

Height of reactor = V/A = 1.8/0.1 = 18 m

Example 4.2. Design a gasifier for a farmer having abundant amount of wood for 1500 kW power generated pump set for 8 hours a day. 1kg of biomass produces 2.5 m3 producer gas with average calorific value 5 MJ/m3 and average calorific value of wood (dry wood) is 20 MJ/kg. Assume SGR, piled density of pump set as 75 kg h-1 m-2, 800 kg/m3 and 0.35 respectively.

Solution:

(i) Gasification Efficiency (ηg) = $\frac{2.5 X 5}{20} X\ 100$

= 62.5% =0.625

Overall Efficiency (η_{oa}) = 0.625 X 0.35

= 0.218 = 21.8%

Fuel consumption or Food Rate, q = $\frac{3600\ Xp}{\eta oa X\ Hw}$

$$= \frac{3600\ X 1500}{0.218\ X\ 20X\ 103} = 12.38\text{kg/h}$$

Quantity of gas produced, Q = $\frac{\eta g X\ q X\ Hw}{Hg}$

$$= \frac{0.625X\ 12.38X\ 20X\ 103}{5X\ 103} = 30.857 \text{ m3/h}$$

Volume of Reactor, V = $\frac{q.t}{Sp} = \frac{12.34X\ 8}{800}$ = 0.1234m^3

Area of reactor, $A = \frac{q}{SGR} = \frac{12.38}{75} = 0.164\ m^2$

Diameter (d) $= \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4X0.164}{3.14}} = 0.45m$

Height (H) $= \frac{V}{A} = \frac{0.1234}{0.164} = 0.75\ m$

Example 4.3. A farmer wishes to operate his 20 kW diesel pump set on the producer gas by replacing 80% oil for 6hrs. in a day. Design an approximate size of gasifier for the following data available. Abundant availability of rice hulls pleated having 3.25 MJ/m3, Calorific value and produces 1.5 m3 gas from 1 kg of rice hulls. pilled density = 100 kg/m^{3}. Engine Efficiency =40%

SGR=150, Kg h-^{1} m-2 and Calorific value of husk =15MJ/kg.

Solution:

Theoretical Power =20kW

Actual Power = 80% of 20 kw

$\frac{80}{100}$X 20 = 16 Kw

Gasification Efficiency $= \frac{1.5X\ 3.25}{15X\ 10} = 0.325 = 32\%$

Overall efficiency, $\eta_{oa} = \eta_g X\ \eta_e = 0.325X\ 0.4 = 13\%$

Feed Rate, $q = \frac{3600X\ \rho}{\eta oaX\ Hw} = \frac{3600\ X16}{0.13X15X\ 103} = 59.5384$ kg/h

Quantity of Gas Produced $Q = \frac{\eta g\ X\ q\ X\ HW}{Hg}$

$Hg = 1200\ kcal/m^3 = 4.2X1200\ kJ/m^3 = \frac{0.325X\ 29.5384X\ 15X\ 103}{4.2\ X\ 1200} = 28.57m^3/hr.$

Volume of Rector, $V = \frac{t.q}{Sp} = \frac{6X29.5384}{100} = 1.77m^3$

Area, $A = \frac{q}{SGR} = \frac{29.5384}{150} = 0.196\ m^2$

Diameter, $D = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4X\ 0.196}{3.14}} = 0.5\ m$

Height, $H = \frac{V}{A} = \frac{1.77}{0.196} = 9.03\ m$

❑❑❑

Microwave Irradiations Impact on Germination of Onion Seeds

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Abstract: The classical methods of seed treatment make use of chemical substance which is either expensive or harmful to the soil. The data presented in this paper demonstrates that exposure to a high intensity electric field can be an effective alternative for chemical treatments. The trials were undertaken for old and fresh seeds of Baswant 780 onion variety. Germination tests were conducted after application of microwave irradiations at different three power levels (720 W, 540W, 360W) for three durations (10 seconds, 20 seconds, 30 seconds). Each seed lot was of 50. Trials were conducted in three replications. Treated seed lots were sealed in 700 gauge polyethylene bags. The observations on seed quality parameters were recorded at monthly interval and bio chemical observations were recorded at bimonthly interval. The study showed 540W for 20 second interval microwave application was found beneficial in comparison with control condition. The data analysis was done using factorial completely randomized design.

Keywords: Microwave, Seed Germination, Plasma, Storage life

I. Introduction

Onion is one of the most important vegetable crops grown in India [1]. It is used as either raw or as spice vegetable in all over the world. Its demand is fairly constant. It is grown in north and south India. Maharashtra, Gujarat, Karnataka, Tamilnadu, Andhra Pradesh, Bihar and Orissa are the onion growing states. Onion is a bulbous biennial herb. Bulbs are formed by the attachment of swollen leaf bases to the underground part of stem vegetable crops. Deterioration of seed is associated with ageing phenomenon which is defined as an irreversible degradation change in the quality of a seed after it has been reached to maturity stage. Its maximum quality level and the seed deterioration also start immediately after attaining the physiological maturity on the plant itself [2].

Unfortunately, the seed quality is often very poor. According to Banergee [3], less than 15 % of fields are sown with quality seeds in India and it has been shown that merely by using good quality seeds, yield could be substantially increased to about 15 to 20 %. Presently the awareness among our farmers lead to use good quality seed but continuous and adequate supply of quality seeds remains to be a major constraints for Indian agriculture.

Good seed is basic input in vegetable production. The seed producers hold greater responsibility in maintaining genetically pure seed and to preserve the quality of seeds from harvest to next sowing. In order to prevent the qualitative and quantitative losses due to several biotic and abiotic factors during storage, electric and magnetic fields are used as a non chemical method in agriculture [4]. Lately, the use of physical methods for plant growth stimulations is getting more general due to the less damaging effects on the environment [5]. It has been perceived that the electric and magnetic fields cause physio – biochemical changes in seeds [6]. Electric and magnetic fields have been reported to affect biological process including free radicals, excite the activity of proteins and enzymes to increase in seed vigour [7, 8]. Additionally, it reduces the toxicity and pollution of surface /underground water. To assess the benefits of such electric field applications in agriculture, the study was planned at Mahatma Phule Agricultural University, Rahuri. This paper discusses about onion seed germination improvement through electric field application.

II. Experimental Procedure

The onion seeds of Baswant 780 variety were collected from seed cell unit, MPKV, Rahuri. Fresh and old seed lots with low vigour were selected to identify the effect of electric field exposure of different intensities for different intervals. The treated seed lots were sealed in 700 gauge polyethylene bags. The observations on seed quality parameters were recorded at monthly interval and biochemical observations were recorded at bimonthly basis.

The equipments *viz.* microwave oven was utilized from Electrical Engineering laboratory; the double door germination chamber, hot air oven, electrical conductivity meter, weighing balance, measuring scale etc. were utilized from Seed Technology Research Unit. The laminar air flow, incubation room, petri dish, forceps, microscope were made available by Seed health testing laboratory. The Department of Biochemistry, MPKV, Rahuri provided their laboratory facilities with digestion chamber and modified Kjeldhal's apparatus, centrifuge machine, spectrometer.

The chemicals required for bio-chemical analysis *viz.*, sulphuric acid, potassium sulphate, mercuric oxide, copper sulphate, sodium hydroxide, sodium thiosulphate, boric acid, hydrochloric acid, methyl red indicator, bromocresol green indicator, monobasic potassium phosphate, dibasic potassium phosphate, hydrogen peroxide, EDTA, was made available by the Department of Botany, MPKV, Rahuri.

The germination trials were conducted in two phases i.e. germination at pot trials and seed germinator. For seed germinator petri dishes and for open field plug trays were used. After conducting feeler trials, the microwave oven was setup for three desired power levels *viz.*, 80 (720 Watt), 60 (540 Watt) and 40 (360 Watt) % each for three time periods i.e. 10, 20 and 30 sec., respectively. Seeds were treated for combination of each power level and time period.

Different observations were recorded at monthly interval to study the effect of electric field application at different power levels and exposure time on seed quality of onion during storage.

III. Laboratory Tests

Several laboratory experiments were performed to determine whether high – intensity electric field exposure improves germination. The influence of microwave irradiation on seeds of onion has been investigated. A microwave; operating on 230V, 50 Hz, single phase supply, 900W maximum power output with operating frequency 2450MHz was used for treatments. The onion seeds for the experiment were distributed in nine lots each containing 50 seeds with three replications. The variants differ by the time of exposure to microwave radiation. Seeds were exposed to the duration for 0 s (control), 10 s, 20 s, 30 s. Microwave radiation with output powers of magnetron – 80%, 60% and 40% were applied.

Group of 50 seeds were subjected to each treatment, for chosen exposure time and analogous groups were used as control. Then onion seeds were cultured in petri dishes for germination trials. The laboratory tests were conducted with the help of following equipments.

1. Microwave
2. Seed germinator having humidity, temperature and light intensity control facility.
3. Oven for dry matter measurement, weighing balance, seed counter, electrical conductivity meter.
4. Miscellaneous material required for actual germination trials such as wax paper, petri dishes, blotting paper, cotton, chemicals etc.

In all, there were ten samples along with one untreated as a control. The germination tests were carried out in seed germinator where temperature and humidity was maintained at 25^0 at 80% relative humidity. Similarly same seeds were sown in the plugs filled with soil having sufficient moisture well suited as open field conditions. In order to estimate the influence of the microwave treatment on onion seed following factors were considered:-

- Germination percentage
- Root- shoots length
- Dry matter content
- Vigour index
- Moisture content
- Electrical conductivity
- Seed micoflora
- Bio chemical analysis
- Statistical analysis

The trials were conducted for seed lots of different years. For fresh seed lot 50 seeds/lot with three replications and for old seed 400 seeds /lot were tested for germination trials at germinator and pot respectively. Based on preliminary tests final trial's parameters were fixed. For other trials, four replications each of 100 seeds from different treatment combinations were germinated using top of paper method (T.P.) at $25 \pm 2\ ^0C$ in germinator for 10 days [9]. The germination percentage was computed on the basis of normal seedling only.

Ten normal seedlings from each of the replication of germination test were randomly selected and root-shoot length was measured in centimeter. The average length was calculated and recorded in centimeter.

Dry matter content was calculated by drying ten normal seedlings (which were used for the recording root-shoot length) at $50\ ^0C$ in hot air oven for 24 hours and the final weight was recorded in gram (g).

The vigour index of the seed lot was assessed by the method suggested by Abdul Baki and Anderson

Vigour Index-I = Average root + shoot length (cm) × Germination (%)

Vigour Index-II = Average dry seedling wt. (g) × Germination (%)

Moisture content was determined by Hot Air Oven Method by drying the 5 gm of onion seeds at 103 °C for 17 hours in hot air oven [9]. The percentage of moisture content was calculated on conventional wet-weight (w/w) basis.

Three replications each of 50 seeds were randomly counted from each treatment and were soaked in 75 ml distilled water for 24 hr. The electrical conductivity of solution was measured by using conductivity meter having cell constant one [11].

The seed health was determined by blotter test [12]. Three layers of blotter paper size fitting to the size of petridish soaked in sterilized distilled water and placed in petridish. Ten no. of seeds was placed in each petridish at equidistance and the petridish was kept in a incubator at 20 ± 2 °C for 12 days beneath near ultra-violet light with a cycle of 12 hours light and 12 hours darkness by maintaining four replications. The seeds were then examined on 12th day under stereoscopic binocular microscope. The fungi were identified on the basis of sporulations and their fruiting structure.

The nitrogen percentage in the seeds was estimated by the modified kjeldhal's method [13]. The onion seed samples from each treatment in three replications were digested in digestion tubes using 0.02 N concentrated H_2SO_4 and 2 % Boric acid. After digestion of samples, 10 ml of an aliquot of digested acid extract was placed in distillation apparatus with 40 % NaOH solution. Then distillation was carried out till all the ammonia is evolved. Then distillate was titrated with standard H_2SO_4 along with blank till the color changes from green to red. Based on this basic routine procedure the treatments are finalized. The data obtained in present investigation was analyzed by using Factorial Completely Randomized Design

IV. Results and Discussions

After the treatment seeds were used for germination trials immediately. The germination percentage were counted as first day count and final count on fourth and fourteenth day as per ISTA standards. Percentage germination, root – shoot length, fresh weight, dry matter weight, seed vigour1 and seed vigour2 were calculated from test results. Table 1 gives the results of germination percentage for the trials conducted.

Table 1: Test Results for Microwave Treatment

Treatment	Germination (%)		Root shoot length (cm)	
	Old	New	Old	New
P1T1	81	87	10.0	11.5
P1T2	74	81	7.1	10.0
P1T3	59	62	6.5	9.1
P2T1	85	91	11.0	12.5
P2T2	88	96	12.8	14
P2T3	83	95	12.0	13.5
P3T1	81	86	9.8	11.2
P3T2	82	90	10.2	11.5
P3T3	86	91	11.5	12
C	78	85	9	11

Treatment P2T2 method (Power level 60% , 20 sec time duration) showed better results from germination, seed vigour point of view. It was found that irrespective of seed lot year microwave impact was observed for almost all power levels as well as time of application. Out of that the method of P2T2 was consistently proved better.

Table 2 : Seed Quality parameters for Old seed

Treatment	EC	Dry matter content (gm)	Mycoflora (%)
Control	0.335	0.03	34
P1T1	0.420	0.03	--
P1T2	0.445	0.02	--
P1T3	0.465	0.02	--

P2T1	0.355	0.03	10
P2T2	0.390	0.03	--
P2T3	0.396	0.02	--
P3T1	0.345	0.03	20
P3T2	0.380	0.02	--
P3T3	0.397	0.02	--

Table 2 shows that electric field application using microwave method was an effective tool to enhance the seed germination maintain seed quality. This was the important aspect from farmers' point of view as onion seeds are too costly. Unavailability of seed was also additional problem. In such cases farmers can use old seed of their own field with this microwave treatment. If they use the untreated old seed, their production will be hampered due to less germination. It reveals that excess seeds may be in use rather than wastage; farmers get benefit by earning good returns from seed/ seedlings/ crop.

The germination percentage, root-shoot length, dry matter content, vigour index I and II and protein percentage were found to be decreased with the advancement of storage period irrespective of seed lot, microwave power level and exposure timing. The electrical conductivity and seed mycoflora were found to be increased with the advancement of storage period irrespective of seed lot, microwave power level and exposure timing. Among the seed lots, fresh seed lot recorded better seed quality throughout the storage period with higher germination percentage, seedling length, dry matter content. vigour index I, II, and protein content and lower electrical conductivity and lower seed mycoflora as compared to old seed lot.

Among the interaction of microwave power level and exposure timing P_2T_2 (P_2 = 60% and T_2 = 20 sec.) recorded better seed quality throughout the storage period with higher germination percentage, seedling length, dry matter content, vigour index I, II, and protein content with lower electrical conductivity and seed mycoflora as compared to other microwave power level and exposure timing interaction.

Table 3: Germination change during storage

Treatment	% Germination after treatment			
	Initial	After 90 days	After 270 days	After 330 days
Control	85.18	80.30	71.00	61.00
P1T1	83.50	78.80	58.00	61.00
P1T2	83.27	80.50	58.00	63.00
P1T3	84.61	82.33	58.00	62.00
P2T1	85.16	82.30	72.00	64.00
P2T2	89.16	85.83	73.00.	67.00
P2T3	86.66	82.83	72.00	63.00
P3T1	82.66	74.00	55.00	62.70
P3T2	84.60	81.83	55.00	62.00
P3T3	86.50	82.83	71.00	63.00

Among the treated and untreated control seeds, treated seeds recorded higher seed quality parameters *viz.*, germination percentage, seedling length, dry matter content, vigour index I, II and protein content and lower the electrical conductivity and seed mycoflora as compared to untreated control seed.

Based on standard practices different observations were noted. From the data, it was revealed that the different microwave power level had significant effect on onion seed germination during all the periods of storage. The microwave power level 60 %, 20 sec (P_2 T_2) had significantly proved better in comparison with all others. It's initial germination of 89.16 % followed by P_2T_3 as 86.66 % and P_3T_3 as 86.50 %. At the end of storage period of 330 days the onion seed germination was decreased to 67%, 63%, 63% respectively for fresh seed lot.

Similar study for old seed showed more enhancing results as 85.30% initially and 64% after storage of 330 days for P_2 T_2 trial condition as 60 % power for 20 sec. interval. For old untreated seed these germination percentages were 73.33 and 49.30% respectively. Hence this study showed significant increment in germination percentage throughout the storage period due to microwave irradiation to seeds. All together every treatment results were encouraging. Relatively P_2 T_2 was found as best treatment.

With consideration of these test results, this technology will help rural development and transform the economical change in these areas. Further research will confirm these things in larger scale for wide adoption.

With respect to national policy for farmers, there is a need to focus more on the economic well- being of the farmers, rather than just on production. In such scenario use of treated old seeds will be beneficial for farmers for gaining benefits. By carrying such research, using electricity in proper way, productivity on farm can be improved to meet increased food demand of huge population.

V. Conclusions

1) The method of electric field exposure for onion seed was found as an effective tool for older seed germination enhancement
2) The application of microwave field reported prominent impact on seed germination as well as storage life
3) Studies showed better results for the treatment of 60 % (540 W) power level for 20 second interval
4) In Indian scenario, there is a need to apply these methods on commercial basis to improve growth, yield and to minimize the fertilizer/ pesticides requirements

Acknowledgment

The author would like to thank Dr. K. J. Kamble, Head, Department of FSRE and Dr. D. D. Pawar, Associate Dean, Dr. A.S. CAET, MPKV, Rahuri for their valuable suggestions. The author acknowledges with thanks to Miss. Gitanjali Katkar for data collection and all concerned faculties as well as staff of MPKV for their co operation.

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Fuelling the Future with Bio CNG - A Review on Production Process, Present Status and Future Scope in India

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Abstract: Bio CNG is an enriched form of biogas consist of 90% methane, carbon dioxide up to 4% and traces of other gases. It has capacity to fulfill the demand of every utility of LPG and CNG in India and has the potential to be the future generation renewable fuel because of the abundance of biomass in the country. Bio-CNG has commercial, industrial and automotive values and can be used in restaurants, cement factories, public transport and CNG-fitted vehicles. Presently, there are 17 Bio-CNG plants operational in India, out of which, Maharashtra tops with five plants while Tamil Nadu has one with a combined capacity of 46,178 kg per day.

Introduction

In India traditionally biomass had been utilised either through direct combustion or anaerobicdigestion. Anaerobic digestion of biomass is the process in which organic matter, in the absence ofoxygen, is mainly transformed into a mixture of methane and carbon dioxide which is usually referred to as biogas. When this mixture is further processed, purified and compressed it is called Bio Compressed Natural Gas (Bio-CNG). It is similar to natural gas in terms of its composition and properties.

Biogas consists mainly of methane (CH_4, 55-65%) and carbon dioxide (CO_2, 35-45%) and the calorific value of biogas is 19500 KJ/Kg. Methane is a valuable form of gas, as it is an efficient energy carrier with a wide range of uses. The amount of CO that is produced corresponds to the amount of CO_2 captured when the biomass was created, making biogas carbon neutral.

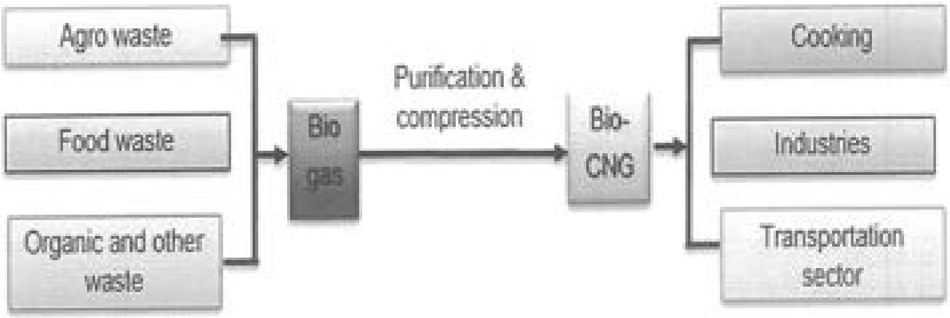
Aside from methane and CO_2, biogas also contains trace components like water vapour, hydrogen sulfide (H_2S), siloxanes, hydrocarbons, ammonia, oxygen, carbon monoxide, and nitrogen. The proportion of these trace components depends on the source of the biomass. The presence of water vapor, H_2S, and CO_2 make biogas very corrosive and unsuitable to be used as fuel. If this biogas issued as fuel in automobiles it can cause erosion of the metal parts, which in turn increases the maintenance cost of the vehicles. In order to tackle this problem the solution that is available is to upgrade biogas.

Biogas upgrading or purification is the process by which contaminants in the raw biogas stream are absorbed or scrubbed, leaving more methane per unit volume of gas. This final product is called biomethane. The most widely used technologies for biogas upgrading are water scrubbing, Pressure Swing Adsorption, membrane, and chemical scrubbing. Of these technologies, water scrubbing and Pressure Swing Adsorption are considered to be most appropriate on a small scale due to low cost and easy maintenance. Biomethane can also be compressed and bottled into cylinders and it is called Bio-Compressed Natural Gas (Bio-CNG).

Compressed biogas is exactly similar to the commercially available natural gas in its composition and energy potential. Given the abundance of biomass in the country, compressed biogas has the potential to replace CNG in automotive, industrial and commercial uses in the coming years. The potential for compressed biogas production from various sources in India is estimated at about 62million tonnes per annum and also help bring down dependency on crude oil imports. The high methane content and calorific value combined with the low quantity of moisture, hydrogen sulphide and impurities makes Bio-CNG an ideal fuel for automobiles and power generation. The low emission levels of Bio-CNG also make it a more environment-friendly fuel than biogas. Bio-CNG also holds great promise for efficient municipal solid waste management and in tackling the problem of polluted urban air due to farm stubble-burning and carbon emissions. The Bio-CNG process also produces enriched organic manure which can be used as fertiliser.

Biogas to Bio-CNG

Biogas is a mixture of different gases produced by the breakdown of agricultural waste, manure, municipal waste, plant material, sewage, green waste, or food waste, in the absence of oxygen. Bio-CNG is produced from biogas, through a simple and convenient process involving desulphurisation, upgradation and compression.Bio-CNG is exactly similar to the commercially available natural gas, next in pressurizing and storage phase in this the purified biomethane is pressurized and filled in certified high-pressure cylinders mounted on the cascades and at the end the bio-CNG, so collected, is ready to be dispensed for use in cooking and housing power supply as well as automobile vehicles.



First, biogas is desulphurised if the hydrogen sulphide content is over 1,500 ppm. Then, the desulphurised biogas is upgraded to make its composition similar to CNG, followed by the compression and bottling of the resulting bio-CNG. Bio-CNG contains about 92-98 % of methane and only 2-8 % carbon dioxide. The calorific value of Bio-CNG is about 52,000 kilojoules (kJ) per kg, which is 167 % higher than that of biogas

The high methane content and calorific value combined with the low quantity of moisture, hydrogen sulphide and impurities makes bio-CNG an ideal fuel for automobiles and power generation. The low emission levels of bio-CNG also make it a more environment-friendly fuel than biogas.

Present Status

Bio-CNG has the capacity to be the future of renewable fuel due to its abundance such as it can replace every LPG and CNG utility in India. In India, Bio-CNG is estimated to replace two-thirds of India's Natural gas imports, which is currently at 429 billion cubic feet. In July 2016, the Waste to Energy Division of MNRE launched a programme on energy from urban, industrial and agricultural wastes/residues which aims to promote setting up of projects for recovery of energy in the form of biogas/Bio-CNG/enriched biogas from urban, industrial, and agricultural wastes. Central Financial Assistance (CFA) of INR 4 crore per 4800 kg of Bio-CNG/day generated from 12,000 cubic metre Biogas /day has been announced, with a limitation of Maximum CFA as INR 10 crore/project).

Presently, there are seventeen Bio-CNG plants operational in India, with a combined capacity of 46,178 kg per day .These plants are spread over nine states, of which Maharashtra leads in terms of the largest capacity as well as the highest number of plants. In addition, the National Agricultural Cooperative Marketing Federation of India is planning to develop a Bio-CNG facility near Azad Mandi in New Delhi.

Future Scope in India

Biomass has the highest potential for small scale business development and mass employment. Opportunities are diverse, and are present in such different sectors as, R&D, agriculture (biomass cultivation and processing), transport services, bioenergy production, and manufacturing. Potential of biogas in the next two decades due to rising waste generation and deployment of infrastructure for improving waste collection efficiency. The analysis estimates that the biogas potential ranges from 310 to 655 billion m^3/year in the year 2040 depending upon availability of different resources.

The estimated biogas potential in the year 2040 is around 36% of India's current (2015) total primary energy supply in the high availability scenario. Finally, the paper offers policy recommendations aimed at realizing the biogas potential.Global employment in RE is expected to increase nine-fold reaching 20 million jobs by 2030, with biomass leading the growth. India has a potential of generating 18 GW of energy from Biomass. Shift towards a decarbonized power sector in India, with coal-sector-based employment expected to decline by about 52 % between 2020 and 2050. Indian Oil, HPCL, BPCL to invest INR 10,000 crore for Bio-CNG plants thereby operating 400 plants by 2022.

There is huge employment opportunity in this area and it can bolster our economic development. The technology is proven. There is a potential of 5,000 bio CNG manufacturing units in India. Tractors running on bio-CNG could help cut down annual fuel cost for a user by around 55%, it doesn't emit any noxious fumes and is 85% less pollution compared to a diesel-run tractor, union transport minister Nitin Gadkari Ji said on Friday 12 February 2021. Gadkari was speaking at the launch of India's first CNG tractor.

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Development of Motor Operated Solar Panel Cleaning Machine

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Abstract: The output power of solar panel reduces due to accumulation of dust on solar panel. The power generation reduces up to 50% if the module is not cleaned for a month. So, in these areas there is no other option than cleaning the PV modules to maintain the constant power output. In this study, the readings of current and voltage before cleaning and after cleaning of solar panel were taken on solar panel of 80 W. The developed motor operated solar panel cleaning machine consists of dual shaft single phase AC motor of 150 W to rotate the brush and a 40 W submersible water pump to lift water and apply water with pressure at panel surface. It is designed to cover 1 m width. The machine has average cleaning efficiency of 70% for 1 complete revolution. It takes four revolutions for complete cleaning of a solar panel of width 1 m. It was observed that highest values of voltage, current and power obtained at 15° tilt angle and when there is no dust accumulated on solar panel. The developed solar panel cleaning machine consumes 0.008-unit electricity for cleaning one panel completely.

Introduction

Electricity is becoming expensive with each passing day and also due to the power cut problems more people are moving towards the alternative sources; among which SPVs is very good alternative. The demand of SPVs is increasing day by day for commercial as well as domestic purpose instead of their high initial cost.

Efficiency of solar panel is limited due like shading loss, wiring loss, sun tracking loss and soiling loss. Among all these losses the most critical one is the soiling loss in a country like India. Soiling loss occurs due to the accumulation of the dust, dirt or other particles on the glass of the PV modules which blocks the incident light from the sun, which leads to less power generation. Hence, in order to increase or maintain the high-power generation from SPV system, they needed to be cleaned.

The power generation reduces up to 50% if the module is not cleaned for a month. So, in these areas there is no other option than cleaning the PV modules to maintain the high-power output.

There are 13 different types of dust that are commonly found in the air and some of them are red soil, cement, ash, carbon, limestone, silica, calcium carbonate, sand, sand clay, soil, mud and coarser mode of airborne dust, and harmattan dust. Out of them ash, limestone, silica, calcium carbonate, sand and soil have greater effect on the PV panel.

Solar power generation can be influenced by many factors. The major factors that reduce or impede the generation of power for the PV panels are; shadows, snow, dust, dirt, bird droppings, pollen and sea salt. According to the research, the daily energy loss along a year caused by dust deposited on the surface of the PV module is around 4.4%. In long periods without rain, daily energy losses can be higher than 20%.

We aim to provide a non-wasteful approach to cleaning commercial sized solar panel systems by using minimal amounts of water and power while requiring little to no maintenance. This system will clean a single row of panels periodically.

Objective

1. To design and fabricate solar panel cleaning system.
2. To conduct performance test and modification and development of the system.
3. To clean the solar panel and increase its power output.

Materials And Method

Components of motor operated solar panel cleaning machine

Cleaning unit

The cleaning unit of the solar panel cleaning system consists of motor and brush and support frame to support brush.

1. AC motor: The machine uses 150-watt dual shaft single phase AC motor.

2. Brushes: The brushes are used for scouring off and removing them effectively. The brushes are made by mounting nylon brush of bristle diameter 0.5 mm and height of 55 mm on the PVC pipe of 38 mm and arranged in spiral manner along the length of pipe with length of each brush roller 460 mm.
3. Support frame: This is the part which provide support to the brush roller fixed on the motor body and supports the other end of the brush roller.

Water pumping unit

It consists of parts used for water supply from water source to the solar panel and cleaning unit. It mainly consists of pump, supply pipes, discharge orifice.

1. Pump: The pump is used to supply water with pressure to the cleaning unit. A 40 W submersible pump is to pump up the water with total head of 2.6 m.
2. Delivery pipe: The water is supplied through clear flexible PVC pipe of 8 mm diameter and 5 m length.
3. Discharge orifice: It is used for Delivering water over the panel surface. The 2 mm diameter hole is drilled on pipe for discharge of water.

Handling unit

It consists of parts used for handling as well as moving the cleaner assembly.

1. Handling rod: It is hollow adjustable pipe used to carry the whole cleaning assembly. It uses 4.5 m long adjustable 25.4 mm diameter rod.
2. Wheels: The wheels are used for the purpose of moving the cleaner assembly on the solar panel surface as well as providing the stability to the machine while operation.

Design calculations

Motor

Power of motor, $P = \dfrac{2 \times \pi \times N \times T}{60}$

Brush roller

Scouring force (F) at tip of brush

$T = F \times r$

Or $F = T / r$

Where T = torque available at the shaft

r = radius of the brush roller

Handling rod

Bending Stress on handling rod,

$\sigma_b = F / A$

Where, F = Bending force acting on rod.

A = area of brush rod

$\sigma_b = F / [\left(\frac{\pi}{4}\right) \times (D_o^2 - D_i^2)]$

Where, D_o = Outer diameter

D_i = Inner diameter

Force, $F = W \times g$

Where, W = Total weight of brush and motor assembly g = acceleration due to gravity

And σ_{bp} = permissible bending stress = 155 – 165 MPa when $\sigma_b < \sigma_{bp}$,design is safe.

Wheels

Weight supported by each wheel when spaced at equal distance

W_w = total weight of the system / no. of wheels

Table 1 : Design parameters of motor operated solar panel cleaning machine

Sr. No.	Design parameter	Value
1	Power of motor	150 W
2	Revolutions per minute of motor	100 rpm
3	Torque on brush	14.33 N-m
4	Scouring force at tip of brush	190.92 N
5	Total weight of brush and motor assembly	39.24 N
6	Bending Stress on handling rod	0.286 MPa
7	Weight supported by each wheel	13.08 N

Design

The design of motor operated solar panel cleaning machine is given in fig. 1 and different parts and their dimensions are shown in fig 2

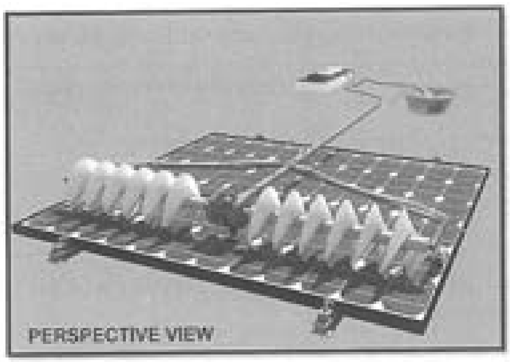

Fig 1: Autodesk 3d max model of motor

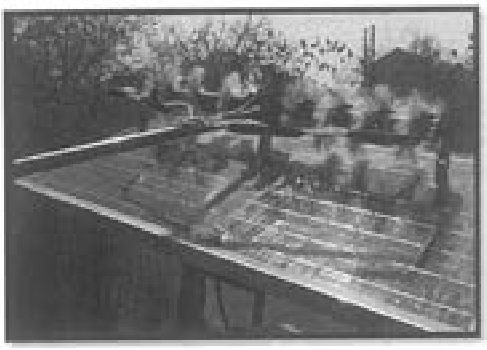

Plate 1: Solar panel cleaning operation

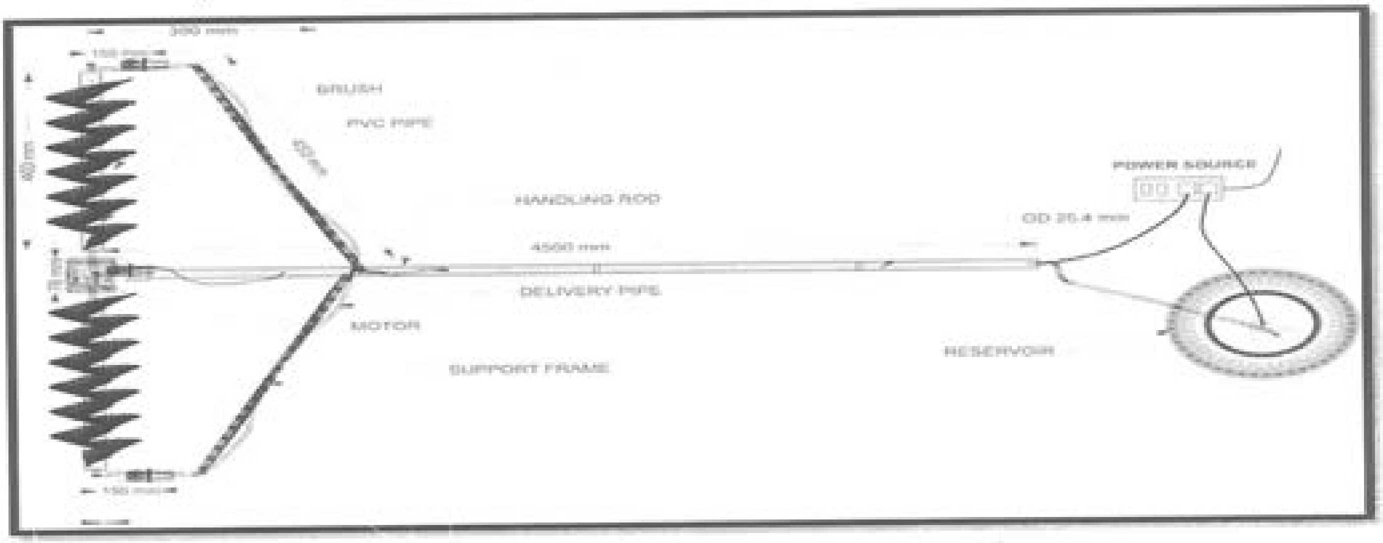

Fig 2: Isometric view of motor operated solar panel cleaning machine

The performance of machine is carried out on 80 W solar PV module. The specification of panel is given in table 2. The cleaning efficiency is observed visually. The value of output current and voltage were taken at different dust accumulation level for tilt angle of 15°, 30°, 45°, 60°, 90° respectively, using multimeter and output power is calculated by equation given below.

$$P = V \times I$$

Table 2: Specification of solar panel used for the testing

Sr. No.	Particulars	Unit	Specification
1	Make		Tata power solar limited
2	Model		TS80 SBJ
3	Peak power (P_{max})	W	80.00
4	Open Circuit voltage (V_{oc})	V	21.80
5	Short Circuit Current (I_{sc})	A	4.90
6	Voltage (V_{mp})	V	17.55
7	Maximum Power Current (I_{mp})	A	4.55
8	Maximum bypass diode	A	9.00
9	Maximum Series Fuse	A	10.00
10	Dimensions (L× W ×H)	mm	1000 × 540 × 20

Results

Table 3: The visual observation of cleaning efficiency of developed cleaning system for different revolutions

Revolution	Average percentage cleaning
After 1 revolution	66.67
After 2 revolution	83.33
After 3 revolution	96.67
After 4 revolution	100.00 (nearly)

Table 4: The visual observation of percentage cleaning of solar panel on different time period given for single rotation of cleaning system

Sr. No	Time (s)	Percentage Cleaning
1	10	50
2	20	65
3	30	70
4	40	70

Table 5: Variation of average output voltage with dust accumulation level at different tilt angle of solar panel

Tilt angle of solar panel	Average voltage output of solar panel at different dust accumulation level (V)				
	0%	10%	30%	50%	80%
15°	21.37	20.64	20.3	20.07	19.77
30°	20.39	20.4	20.3	19.75	19.74
45°	20.19	20.2	19.75	19.72	19.67
60°	20.11	20.11	19.45	19.64	19.63
90°	19.98	19.96	19.42	19.49	19.53

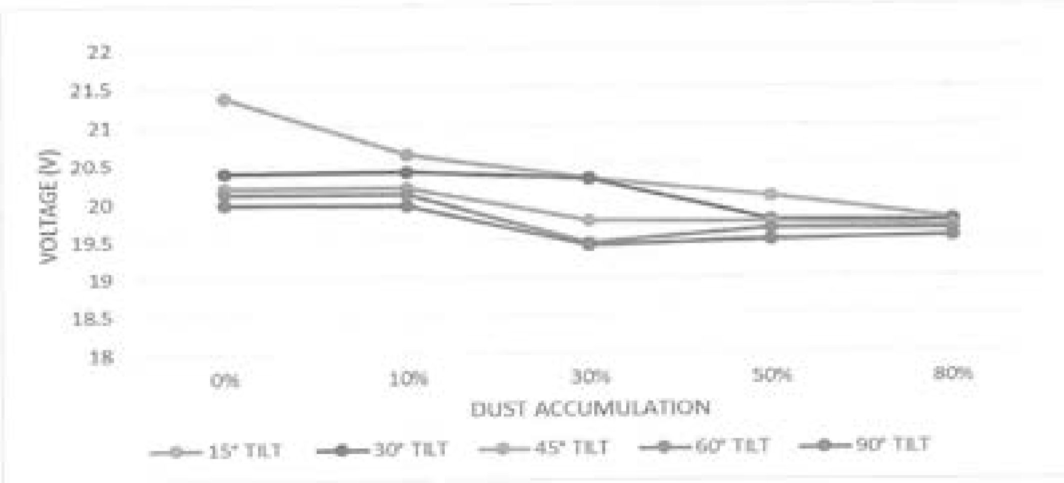

Fig 3: Variation of average output voltage at different percentage dust accumulation for different tilt angle

Table 6: Variation of average output current with dust accumulation level at different tilt angle of solar panel

Tilt angle of solar panel	Average current output of solar panel at different dust accumulation level (A)				
	0%	10%	30%	50%	80%
15°	3.62	2.95	2.67	1.92	1.71
30°	3.42	2.84	2.21	1.75	1.67
45°	3.31	2.73	2.15	1.69	1.57
60°	3.21	2.52	1.80	1.61	1.42
90°	3.11	2.29	1.65	1.45	1.39

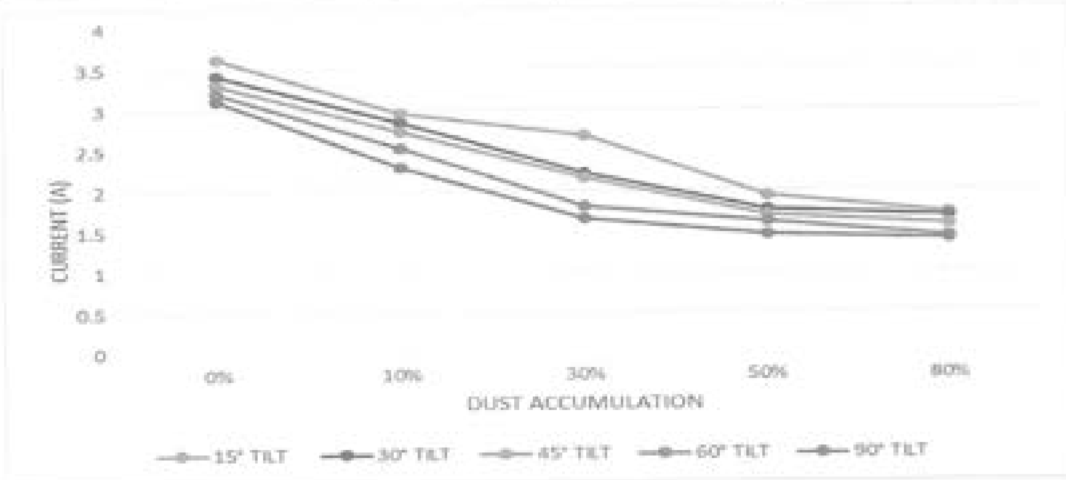

Fig 4. Variation of average output current at different percentage dust accumulation for different tilt angle

Table 7: Variation of average output power with dust accumulation level at different tilt angle of solar panel

Tilt angle of solar panel	Average voltage output of solar panel at different dust accumulation level (W)				
	0%	10%	30%	50%	80%
15°	77.36	60.89	54.2	38.53	33.74
30°	69.74	57.94	44.86	34.56	32.97
45°	66.83	55.15	42.42	33.33	30.82
60°	64.55	50.68	35.01	31.62	27.88
90°	62.14	45.71	32.04	28.26	27.08

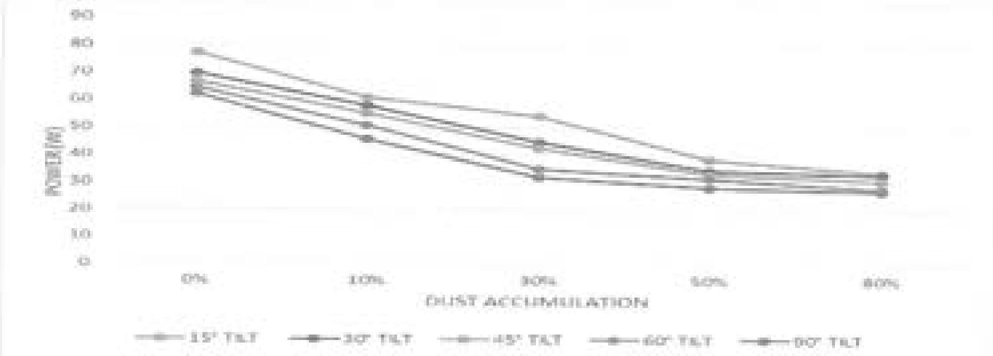

Fig 5. Variation of average output power at different percentage dust accumulation for different tilt angle

Conclusions

The maximum average cleaning of 66.67% is obtained in one revolution of the machine over the solar panel. It takes four revolutions of the machine over the panel for complete cleaning of solar panel. The maximum percentage cleaning of 70% is obtained when it is operated for 30 second for one revolution of machine over the solar panel and for further increase in time does no increase cleaning efficiency. The energy consumption for completely cleaning a solar panel of dimension 1000 mm × 520 mm is 0.008 kWh i.e. 0.008 units. The average daily dust accumulation on solar panel of area 100 cm^2 decreases with days. Total amount of dust accumulation i.e. projected dust accumulation increases over the period of days. The output voltage, current and power reduces when the dust accumulation on the solar PV panel increases. For 80 W panel maximum power of 77.36 W at 15° tilt of solar panel is obtained after cleaning. The average output power decreases to 33.37 W at 15° tilt of solar panel after 80% dust accumulation. The more output power is obtained when the machine is operated with water in comparison to operation without water. The water consumption for cleaning one panel of dimension 1000 mm × 520 mm is obtained as 360 ml.

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Turmeric Harvesting : Design and Development Aspect

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Introduction

Sustainable development in agriculture can be achieved by use of mechanization in agriculture. Mechanization can help in increasing the production by timely farm operations, reducing losses and reducing cost of operations. The labour cost of harvesting of turmeric accounts for well over 30 to 40 % of the total cost of production (Ramtahal, 1971). It has been estimated that two to eight times more man hours are required for hand harvesting of root crops than for all other growing operations (Ramtahal, 1971). It is estimated that a 10% increase in tractive power, and a 15% rise in speed would necessitate a 25% decrease in daily working time (Oyeladeet *al.*, 2003).Mechanization of tuber harvesting is needed as traditionally, well mature bulbs are harvested by hand shovel (khurpi) which is required 21.4% of total expenditure of tuber cultivation.

Material and Methods

Design consideration

1. The ridge to ridge distance is adjustable in the range of 70-90 cm and plant to plant distance is 30 to 60 cm.
2. The plant geometry of turmeric crop is 45 x 30 cm.
3. The machine should be able to harvest the rhizomes efficiently available at different depths from 16 to 24 cm.
4. The width to depth ratio of the working blade as per the crop specification is chosen to be 6:2 (Godwin and O'Dogherty, 2006).
5. The soil moisture at the harvesting time should be in the range of 10- 25%

Crop Parameters

Crop geometry

The plant to plant spacing was 30 cm and row to row spacing was 60 cm.

Rhizome spread

The range of rhizomes spread laterally was 20 to 32 cm and corresponding vertical spread was 10 to 18 cm.

Moisture content of rhizome at digging

The average value of the moisture content was 75 per cent (wb).

Soil Parameters

The soil resistance values are given in (Table1)

Table1 : Soil resistance values of soil.(Kepneret *al.* 2005).

SN	Type of soil	Soil resistance (Kg/cm^2)
1	Sand soil	0.2 to 0.5
2	Sandy loam	0.3 to 0.65
3	Heavy soil	0.7
4	Clay soil	0.35 to 0.8

Bulk density

Bulk density of the soil for the RUGUR or black cotton soil was considered in the range from the literature as 1.16 to 1.28 g/cm^3 (low and high) and average density of soil is taken in calculation (Khura, *et al.* 2011).

Power for turmeric harvester

The proposed machine was to work in the black cotton soil and the travel speed of operation are 1.5, 2.0, 2.5 km/h. Soil Resistance for black cotton soil = 0.75 kg/cm². (Kepner, *et al.* 2005). The draft for the calculation was considered as 500 kg for medium soil (Jain, 2000).

The basic draft and speed of operation of the machine ensure the draft requirement of the machine in field operation (Gill and Berg, 1968).

$$D = D_0 + k\,v^2$$

Where, D = Draft, N

D_0 = Basic draft independent of speed, Kg

v = Speed, Km/h

k = For digger type machine is 3.67

Determination of Soil Load on Turmeric Harvester

Harvester must support its work in soil means to cut the soil slice including the root crop as per the design calculation. The proposed length of the harvester including the cutting blade and the web was decided as per the design.

Thickness of soil cutting blade

The thickness of blade should be 1/10 of the width of blade (i.e. 70 mm).(Rautaray, 1998).

Design Component of Turmeric Harvester

The details of the every components is given with respect to the materials was used for fabrication. The design diagram of the harvester is depicted in fig. 1.

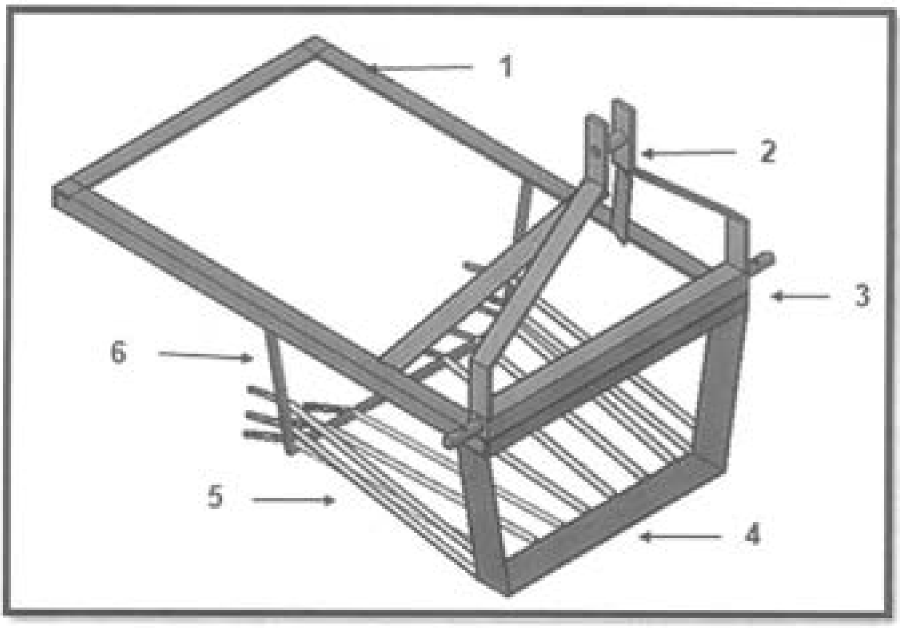

Fig 1.Complete isometric view of tuber crop harvester

SN	Components		
1	Main Frame	4	Soil cutting blade
2	Three point linkage	5	Webs/windrowing
3	Hitch unit	6	Webs supporting Rod

Table 2 : Various materials required for the fabrication of the turmeric harvester.

SN	Component	Size	Material of construction
1	Soil cutting blade	1100 x 70 x 08 mm	High carbon steel
2	Frame	35 x 35 x 05 mm	M.S. Angle
3	Webs	10 mm φ, x 500 mm	M.S. Round
4	Supporting web rod	12 mm φ, x 104 mm	M.S. Round
5	Flat plate	540 x 40 x 10 mm	M.S. Flat
6	Supporting flat plate	500 x 32 x 05 mm	M.S. Flat
7	Hitch	600 x 25 x 25 mm	M.S. Square bar

Working of turmeric harvester

The developed harvester is attached to the small size tractor (18-24 hp) by three point linkage. The machine is operated on forward or pulling force principle to disturb the soil mass effectively. The soil cutting blade of trapezoidal section is inclined at an angle of 25°with horizontal surface of ground, which penetrates in to the soil up to the depth of 18-20 cm with the effective working width of 600 mm. The soil mass and rhizomes uprooted by the blade passes over the web which is having an inclination of 10°with upper surface of soil cutting blade and a length of 500 mm. The loosen soil mass and the turmeric rhizomes after travelling at 270 mm raised height at the end of web fall on the ground surface. The uprooted turmeric rhizomes are easy to collect from the field.

Wearing of Turmeric Harvester

After the field operation of turmeric harvester the data of wearing of various components like soil cutting blade and webs was collected. The size of each component has been measured by means of vernier scale. The reading is taken at different length and different positions to analize the wearing of blade and webs (Anon, 2012 (B))

Results & Discussion

Power for Turmeric Harvester

The adequate power for the effective working of machine is of prime importance.

Table 3 : Relation of travel speed and the power requirement

SN	Forward speed, km/h	Draft, N	Drawbar Power, hp	PTO power, hp	Difference of PTO power, hp
1	1.5	4519.95	2.52	5.30	3.81(71.88%)
2	2.0	4583	3.41	7.16	
3	2.5	4663.96	4.34	9.11	

Determination of Soil Load on Turmeric Harvester

The turmeric harvester has to work in the soil means to cut the soil slice including the turmeric rhizome.

Table 4 : Relation of travel speed and movement of soil as load on the web of harvester.

SN	Travel speed, km/h	Movement of soil volume , m^3/sec	Mass displacement, kg/sec	Soil working capacity at different travel speed, Tone/h	Difference Average volume of soil, m^3/sec
1	1.5	0.044	54.04	194.54	0.029 (65.90%)
2	2.0	0.058	72.05	259.38	
3	2.5	0.073	90.06	324.21	

Thickness of Soil Cutting Blade

Rautaray, 1998 suggested that the blade thickness should be 1/10th of the width of the blade material. As the width of selected blade material is 70 mm hence the thickness comes 7 mm for proper functioning of the blade during life period

Field Performance of Turmeric Harvester

The turmeric harvester was tested at Dr. PDKV., Akola and at farmer's fields.

Table 5. Test condition and other details for mechanical harvesting of turmeric crop

SN	Parameter	Turmeric harvester							Avg.
A	**General**								
1	Crop	Turmeric							
2	Test No.	Test – I	Test –II	Test – III	Test – IV	Test - V	Test - VI	Test - VII	-
3	Variety	Salem	Salem	Salem	Salem	Salem	Salem	Salem	-
4	Testing Farm	Borgaon - 1, Akola	Masa, Akola	CRS, Akola	Sonkhas, Akola	VaniRamb hapur, Akola	Borgaon, 2 Akola	Mangalsa Washim	-
5	Farmer Name	Dr. Amol Ingle	Mr. Pravin More	-----	Mr.Panjabr ao Mule	Mr.Amol Muley	Mr.Subhas Shekokar	Mr.Gunvantr ao Pakdhane	-
B	**Crop condition**								
1	Date of sowing	25/05/012	15/06/012	23/06/012	20/05/012	20/06/2012	07/06/012	14/06/012	-
2	Date of Harvesting	14/03/2013	30/03/2013	7/03/2013	26/03/2013	11/04/2013	29/03/2013	3/04/2013	-
3	Row spacing, cm	80	60	80	80	80	60	60 to 80	-
4	Plant spacing, cm	30	30	30	30	30	30	30	30
5	Plant population/m^2	5.53	6.63	4.83	6.37	7.78	8.78	9.07	7.00
C	**Field condition**								
1	Depth of Digging, cm	20.5	20.2	20.6	20.2	20	20	20	20.2
2	Effective working width, cm	80	80	80	80	80	80	80	80
3	Soil moisture, %	16.53	23.98	11.77	10.52	12.75	11.8	14.42	14.54
4	Slip, %	16.67	20	14.35	13.04	14.89	13.42	15.07	15.39

Table 6. Digging efficiency of tractor mounted turmeric harvester

SN	Parameter	Test – I		Test - II		Test - III		Test - IV		Test - V		Test – VI		Test - VII		Avg.
1	Speed, km/h	1.61		1.65		1.74		1.76		2.00		2.46		2.7		1.99
2	Samples	1	2	2	2	1	2	1	2	1	2	1	2	1	2	
3	Dugout wt., (kg)	2.7	1.11	1.3	4.16	2.46	1.75	2.00	1.005	1.66	1.89	4.1	5.6	4.09	5.575	2.81
4	Undug, wt /m^2,(kg)	0.033	0.012	0.019	0.049	0.027	0.026	0.03	0.013	0.017	0.02	0.029	0.059	0.045	0.044	0.03
5	Damage, wt/m^2	0.025	0.02	0.015	0.05	0.014	0.023	0.07	0.005	0.05	0.025	0.03	0.055	0.035	0.05	0.03
6	Total wt./m^2, (kg)	2.73	1.12	1.32	4.21	2.49	1.78	2.03	1.02	1.68	1.91	4.13	5.66	4.14	5.62	2.84
7	Digging efficiency, (%)	98.90	99.11	98.48	98.81	98.80	98.31	98.52	98.53	98.81	98.95	99.27	98.94	98.79	99.20	98.82
8	Damage percentage, (%)	0.92	1.79	1.14	1.19	0.56	1.29	3.45	0.49	2.98	1.31	0.73	0.97	0.85	0.89	1.32

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Comparative Study of Different Solar Dryer For Drying of Wood Apple

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Abstract: An attempt was made to study the dying of wood apple by using direct solar dryer, indirect solar dryer and open sun drying. As wood apple contains lot of nutritional value and therefore it has to be preserved. Water content is considered the main reason for microorganisms' growth which leads to putrefaction. There are many methods for this preservation but drying process is the most common method of food preservation because it increases the shelf-life of the food. The pulp of the wood apple was placed inside in both the dryers as well as in open sun. The trend of various operating parameters with respect to time was observed. The tests were conducted from 10:00 h to 15:00 h as per the availability of sun. It was observed that that the wood apple was dried within 7 daylight hours from initial moisture content 80 per cent w.b. to final moisture content about 10 per cent w.b. in direct solar dryer, 12 daylight indirect solar dryer whereas in open sun drying it required 16 daylight hours. It was concluded that the direct solar dryer was found to be more efficient in removing the moisture from the pulp of the wood apple.

Keywords: Wood apple, direct solar dryer, indirect solar dryer and open sun drying.

Introduction

Fruits and vegetables are the most important products in agriculture sector. Wood apple is a commonly found fruit in Indian Sub-continent. It is known as *Bael* in various Indian local languages. In comparison to other edible fruits it has longer edible time period of storage if outer shell is not being removed (unprocessed). In north-eastern part of India it can be harvested from mid of November to end of March. Fresh pulp contained 75.16 % moisture (*Sharma et al.*, 2014). Drying is a water removal process from foodstuffs commonly used for preservation and storage purposes. It is one of the oldest technology to preserve the perishable food (*khalloufi et al.*, 2010). It facilitates inhibition of micro-organisms, increases storage capacity and reduces transportation freight (Sayed *et al.*, 2017). For drying purposes various methods emerged in current technologies. Solar drying is the oldest amongst them with less scientific technique cheapest cost and handsome profitable output. In 7 hours continuous drying in one full sunny day under the same climatic condition and same time the solar dryer removed a maximum of 49% moisture content from inside drying chamber for drying low moisture content food products (Baloraj *et al.*, 2013). The National Solar Mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge. Increasing population pressure on land will result in shrinkage of cultivated area. By 2025 AD estimated additional population will be about 178 lakh. This population will require about 2 lakh hectares for habitation alone (Assam Vision 2025). There will be huge requirement of food for this additional population. In order to meet this requirement, vertical increase of production will remain a pressing necessity during next 25 years. Therefore there is an urgency of how to process food so that its shelf life increases up to maximum and by which method it can be done with low cost and user friendly technology. Three different drying methods were adopted in this research work i.e., open sun drying method, indirect solar dryer and direct solar dryer.

Materials and Methods

Sample Preparation

The experiment was performed at Department of Agricultural Engineering, Assam University, Silchar. The raw material i.e. wood apple was collected from Irongmara market, Dorgakona, Silchar (Assam) and is shown in Fig. 1. The samples were stored in a refrigerator until use. The hard outer covering of wood apple was removed by manually breaking it. The edible pulp was scooped out with spoon and seed removed manually. The only edible part was measured with electronic weight balance and divided into three equal proportions of 500 g each. These samples were used for drying under direct, indirect and open sun drying and are shown in Fig. 2.

Fig. 1 : Fresh wood apple

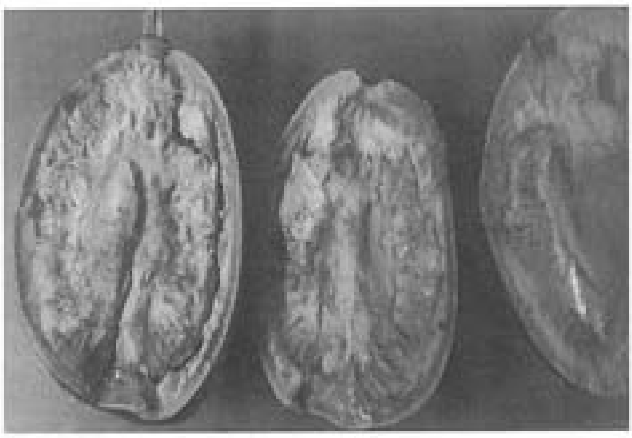


Fig. 2 : Pulp ofwood apple

Direct solar dryer, indirect solar dryer and open sun drying

The known quantity of material i.e. wood apple was placed inside the direct solar dryer, indirect solar dryer as well as in open sun for drying. The performance of thedirect solar dryer, indirect solar dryer and open sun drying has been studied.The trend of various operating parameters with respect to time was recorded. The tests were conducted from 10:00 h to 15:00 h as per the availability of sun and the hourly data was recorded. The drying rate, weight losses and removal of moisture content have been studied and analyzed.

Working principle:

Direct solar dryer i.e. cabinet type solar dryer

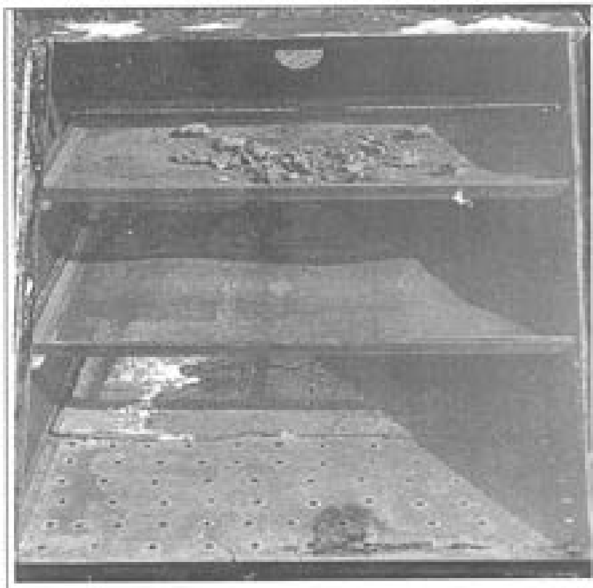
In direct solar dryer, the solar radiations falls on the glass surface some of incidence solar radiation was reflected back to atmosphere and remaining enter inside the dryer, the thermocole sheet was placed inside the solar dryer and it was black painted to absorb the incident solar radiation. Due to this the air inside gets heated up and it flows from the inlet to the outlet by natural convection process. The principle of it is completely based on continuity and Bernoulli formula which causes a force due difference in density. The process produces temperature difference between the inside and outside cabinet air. From the inside chamber, heated air picked up moisture from the product as it passes through the trays and taken away by the air entering into the drying chamber from the inlet provided at the bottom of the dryer and coming out through the outlet provided on the opposite wall of the dryer. The technical specification of the direct solar dryer and the pictorial view is shown in Fig. 3.

Indirect solar dryer

The essential components of the dryer are air inlet (air vent), drying chamber and chimney discharging air at upper elevation. Collector area was painted with black colour to absorb more solar radiations. The chimney was provided to remove the moisture evaporated and to create the draft. In indirect type solar dryer, the heated air in the drying chamber was passed through the bed of the sample at the same time the top surface of the sample absorbed the solar energy directly through a transparent cover. The ambient air enters the drying or heating chamber air got heated and the heated air expands dal it becomes relatively light. The light air was then impelled upwards by buoyancy force, which was equal to the weight of the ambient air displaced by lighter inside air. The wood apple slices were dried simultaneously by both convection and conduction principal. The technical specification of the indirect solar dryer and the pictorial view is shown in Fig. 4.

Open sun drying

The pretreated wood apples were placed on stainless steel plate. Drying was performed under direct sunlight. The atmospheric humidity and ambient air temperature during drying was recorded by digital thermo hygrometer. Moisture loss was recorded at 0.5 h, 1 h, 2 h and so on interval of drying till a constant weight was obtained; no measurement was made during night. The wood apple in sun drying is shown in Fig. 5.



Technical specifications

Area of Collector: 0.5476 m^2 (740 mm x 740 mm)

Drying Temperature : 27 to 52 °C

Number of Inlet holes: 72 No.

Inlet hole Diameter: 10 mm

Exit hole diameter: 70 mm

Air Circulation: Natural

Drying Period : 2 to 3 Days

Application: Drying of vegetables, fruits, flowers and other materials

Fig. 3 Direct solar dryer

Technical specifications

Area of Collector: 0.60 m^2

Length of dryer, L: 1 m

Width of dryer, W: 0.60 m

Number of trays: 3 No.

Diameter of exit holes: 20 mm, 20 holes

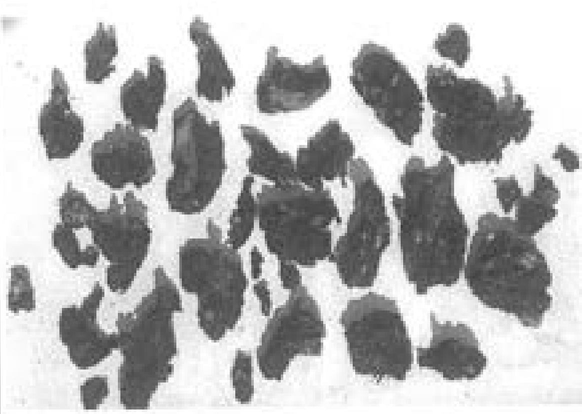
Drying Temperature : 27 to 52 °C

Drying Period : 2 to 3 Days

Air Circulation: Natural

Application: Drying of vegetables, fruits, flowers and other materials

Fig. 4 Indirect solar dryer



Technical specifications

Area of dryer: circular plate 80 mm radius drying area

Drying place: Open space with no shadow nearby

Drying temperature: 23 to 29 °C

Drying period: 2 to 4 Days

Air Circulation: Natural

Application: Any type of fruits and vegetables or any other material for moisture removal

Fig. 5 Open sun drying of wood apple

Analysis

The data was recorded initially after 30 min, 1 hour, 2 hour and so on in same pattern until sun set. The drying rate, weight losses and removal of moisture content have been studied and analyzed.

Moisture content

The moisture content was determined by using AOAC (1980) official method. The dryer was pre heated for 30 min., and then the sample was put inside the drying chamber. Before drying the weight of the sample was recorded. It was subjected to dry for 0.5 h and weight recorded then after 1 h interval same procedure was followed. In the same pattern, the procedure was followed until three consecutive values of weight are same. The moisture content of the wood apple was determined by following formula.

$$MC(\%\,wb) = \frac{W_1 - W_2}{W_1} \times 100$$

Where, MC = Moisture content, %, W_1 = Initial sample weight, g, W_2 = Final sample weight, g.

Observation of temperature

The weighed wood apple pulp was taken on trays and kept inside the both the solar dryer and open sun drying. The ambient air temperature was recorded by using K-type thermometer. The hourly observations like temperature inside the two different solar dryers were recorded.

Results and Discussion

In this drying comparison, the product was subjected to the sunlight in three different drying methods. The two solar dryer consists of closed chamber, blackened from the inner side to act as an absorber but for open method the product was just kept open under sunlight. The moisture removal of three different methods and the final triplicate constant reading was recorded as final data is shown in Table 1. The product after drying by direct solar dryer, indirect solar dryer and open sun drying is shown in Fig. 6, Fig. 7 and Fig. 8.

Table 1: Moisture removal of three different methods

Parameters	Direct solar dryer	Indirect solar dryer	Open Sun Drying
Initial weight (g)	500	500	500
Final weight (g)	157.03	158	158.63
%MC in w.b.	68.59	68.40	68.27

It was observed from the above figure that the wood apple was dried from initial weight on day 1 the initial weight was 500 grams in all three methods and reduced to 157.03 g in direct solar dryer within 7 hours of continuous drying. On day 2, in indirect solar dryer it was reduced to 158 g and on day 3, in open sun drying it was reduced to 158.63 g. It was observed that in open solar drying method, the required final moisture content was attained in 16 h of daylight sun, in indirect solar dryer it required nearly 12 hours whereas in direct sunlight it required only 7 hours. Also, the removal of moisture content was at its highest magnitude in initial period of drying. As the drying day proceeded, moisture removal was slowed down subsequently. The temperature recorded during the different drying methods of wood apple is shown in Fig. 9.

Fig. 6 Product from open sun drying

Fig. 7 Product from in-direct solar dryer

Fig. 8 Product from direct solar dryer

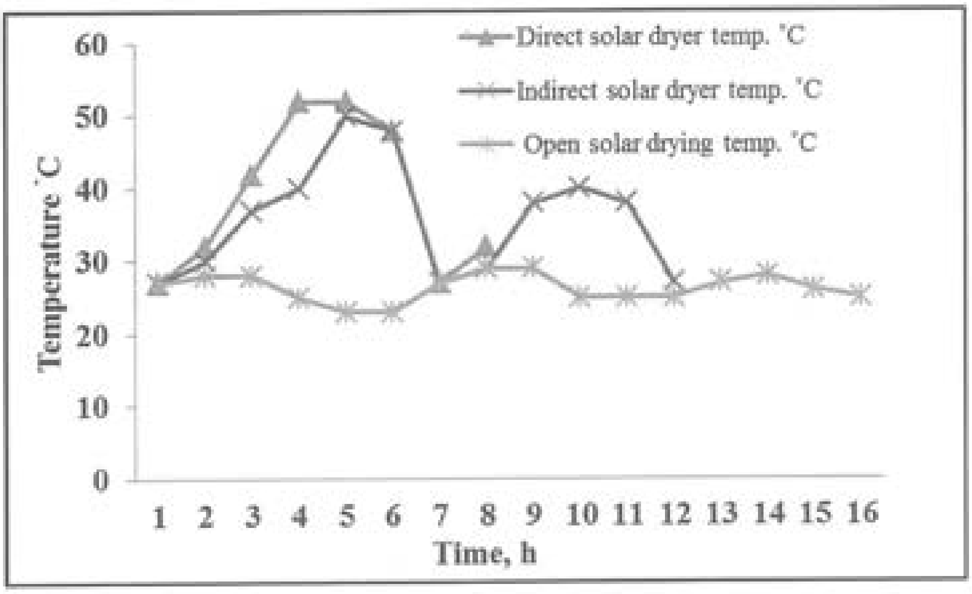


Fig. 9 Temperature recorded during the drying of wood apple pulp

The result showed that direct solar dryer can remove moisture from the pulp of wood apple faster than indirect solar dryer and open sun drying. It can completely remove moisture from wood apple pulp within 7 hours of continuous drying under normal sunlight of 27 to 29 ˚C whereas the indirect solar dryer took around 14 hours and open sun drying took more than 20 hours to completely remove the moisture.

Conclusions

Solar drying system is an enclosed system that could keep the food safe from damage from birds, insects, microorganism and unexpected rainfall. It was concluded that the performance of the drying process in the direct solar dryer was better compared to indirect solar dryer and open sun drying. It was observed that that the wood apple was dried within 8 daylight hours from initial moisture content 80 per cent w.b. to final moisture content about 10 per cent w.b. in direct solar dryer, 14 daylight hours from initial moisture content 80 per cent w.b. to final moisture content about 10 per cent w.b. in indirect solar dryer whereas in open sun drying it required 20 daylight hours from initial moisture content 80 per cent w.b. to final moisture content about 10 per cent w.b. Out of three different drying method the direct solar dryer was found to be more efficient in removing the moisture from the pulp of the wood apple. Moreover it was also observed that some fungal infection was occurred in case of open sun drying method, this might have occurred due to inadequate moisture removal during open sun drying.

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Groundwater Development Through Drainage Line Storage Structures and Reuse of Harvested Water in The Micro-Watershed for Increasing The Yield and Income

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Abstract: The study was undertaken to study the impact of rainwater harvesting structure on groundwater seasonal fluctuations at Kajaleshwar-Warkhed watershed of Tq. Barshitakli, Distt. Akola in Maharashtra. The work of Nala deepening and repairs of rainwater harvesting structure was completed for quantification of groundwater recharge and agricultural development in the dryland area of the watershed. Groundwater level data has been collected from observation wells for knowing rainwater harvesting impact on groundwater regime in watershed area. The groundwater levels data were monitored for groundwater analysis. Groundwater fluctuation maps have been generated from interpolation techniques in Arc GIS 10.3 software. Based on the observed data it was inferred that the average groundwater levels in the 51 wells during the year 2019 was increased by 3.44m as compared to the groundwater levels of the initial year 2016 and the increase was by 0.92m as compared to the year 2018. This is due to the storage of rainwater in the widened and deepened nala for longer duration. The recharged water in the wells was utilized for protective irrigations to different crops. Increase in yield of different crops has been noticed. Also the area under irrigation was also observed to be increased.

Keywords: impact, rainwater, structure, yield

Introduction

Soil and water are the most important natural resources on which survival of humans depend. Groundwater is one of the major resources necessary for the overall socio-economic development and management of any area and it requires careful development and proper investigation of groundwater level. Groundwater resources evaluation in many areas of the country is important for the developmental strategies of integrated watershed development and management. The extensive spatial-temporal changes in the occurrence of ground water resources warrant scientific exploration to locate best sites for tapping this valuable resource. It has many other advantages over surface water. Fast industrial growth, urbanization and rise in agricultural manufacture have led to freshwater lacks in many parts of the world. For suitable supply of water for various purposes like agronomic, domestic and industrial, a greater importance is being laid for a planned and optimal utilization of water resources. The water intake for agriculture, municipal and industries is higher than the yearly recharge. This may lead to reduction of ground water (Magesh et al., 2011; Thomas et al., 2012; Selvam et. al. 2012, Rangarajan 2009). The remote sensing technology can be combined within a GIS environment for a successful description and management of watershed functions and conditions (Khadri and Kanak Moharir 2015 and Khadri and Chaitanya Pande 2016). Minor et. al. (1994) has developed an integrated analysis plan to describe groundwater resources and groundwater management for monitoring and identification of observation well locations in Ghana with the help of remote sensing, GPS and GIS technology. Soil and water conservation structures include all mechanical or structural measures that control the velocity of surface runoff and thus minimize soil erosion and retain water where it is needed.

Groundwater is very important component of the hydrological cycle. It is an important source of water for drinking, domestic, industrial and agricultural uses. It plays a key role in meeting the water needs of various users sectors in India. Ground water resource is contributed by two major sources, rainfall and seepage. A man-made effort through artificial recharge for water conservation structures adds to the ground water. Rawala had suggested suitable methods to recharge the lower aquifer and estimate the approximate amount of water that can be recharged in the area (Rawala, D. et al., 2016).

Objective

- To create geo-spatial database on water harvesting potential in different agro-ecological regions of the country.

Methods

Study Area:

The Kajaleshwar-Warkhed watershed is situated in Barshitakli taluka of Akola district in Maharashtra state situated between 20°13'59"N latitude and 77° 13'23'' E longitude and at an altitude of 337m above M.S.L. with an average annual rainfall of 850 mm. The important aquifers in the area are basalt rock. Basalt, when weathered and fractured contain considerable amount of groundwater.

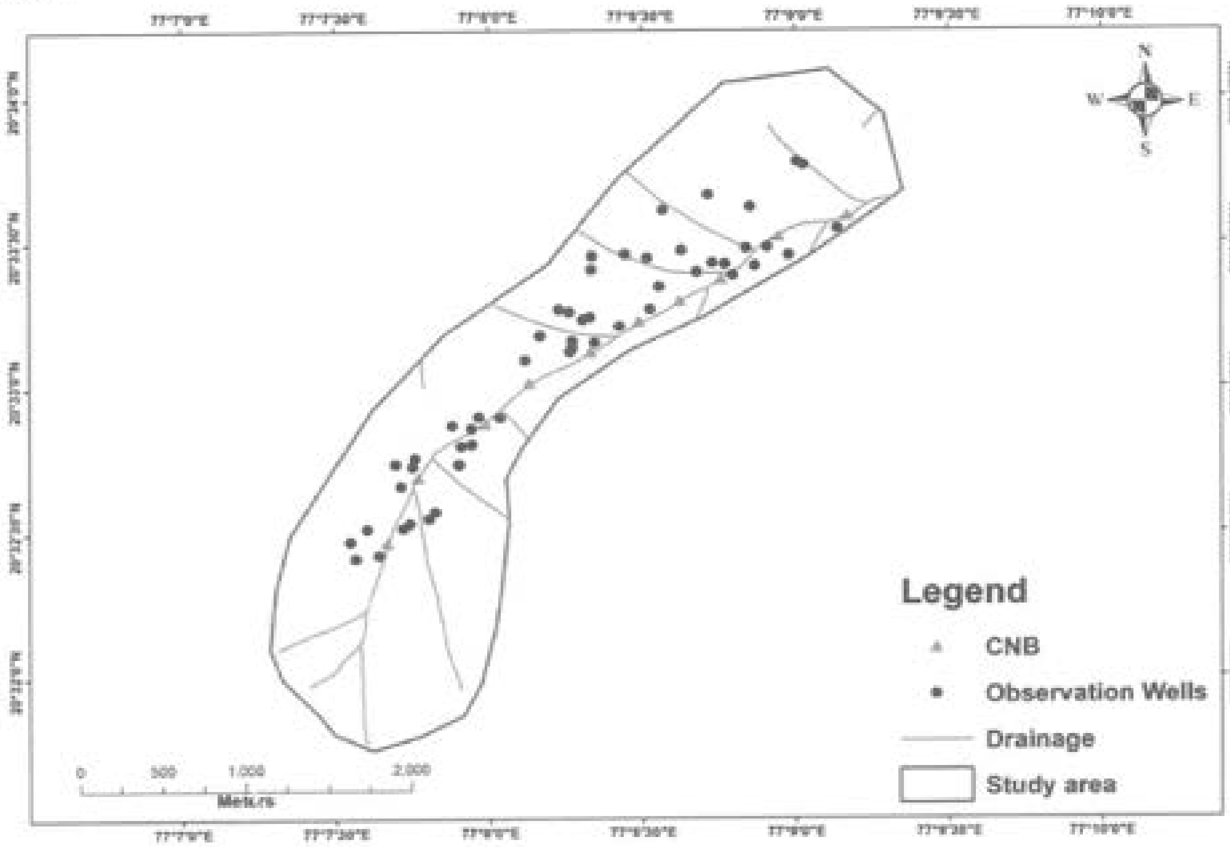

Fig. 1 : Location map of the watershed area

Groundwater level data was collected from 51 observation wells through water level indicator in the vicinity of 10 CNBs (Fig. 1) for analysis of rainwater harvesting impact on groundwater regime in watershed area.

Results and Discussions

Groundwater Level Analysis

Groundwater level data has been collected from 51 observation wells in the vicinity of 10 CNBs for analysis of rainwater harvesting impact on groundwater regime in watershed area. It was observed that, during 2018 (51 wells) average depth of water level (Fig. 2) was 3.73 m and during 2019 (51wells) average depth of water level (Fig. 3) was 2.81 (Table 1). The groundwater level fluctuations in 2019 as compared to 2018 were observed. The well water levels were observed to be increased in 2019 as compared to 2018 for maximum wells. The average depth in the wells in 2019 was increased by 0.92m with respect to the levels in 2018 and by 3.44m as compared to the well levels during 2016 (Table 2 & Fig.4).

Table 1 : Groundwater Levels Fluctuations in 2019 w.r.to 2018

Well No.	Average Depth of water level (m) during 2018	Average Depth of water level (m) during 2019	Fluctuations in depth (m) in 2019 w. r. to 2018
1	3.87	2.90	0.97
2	2.66	2.23	0.43
3	4.15	2.63	1.52
4	3.08	2.13	0.95
5	4.58	3.47	1.11
6	3.92	3.14	0.78
7	3.96	3.07	0.89
8	3.6	2.96	0.64
9	3.38	2.21	1.17
10	3.2	2.53	0.67
11	3.17	2.75	0.42
12	2.48	1.76	0.72
13	2.92	2.04	0.88
14	2.55	2.26	0.29
15	3.4	2.57	0.83
16	4.02	3.21	0.81
17	4.13	3.73	0.4
18	3.08	2.40	0.68
19	2.97	2.02	0.95
20	2.82	2.29	0.53
21	3.33	2.54	0.79
22	4.07	2.22	1.85
23	4.13	3.53	0.6
24	4.78	4.16	0.62
25	3.17	1.63	1.54
26	3.59	2.24	1.35
27	3.92	2.54	1.38
28	4.25	3.43	0.82
29	3.83	2.63	1.2
30	3.8	2.30	1.5
31	4.38	3.54	0.84
32	4.4	3.29	1.11
33	3.95	3.66	0.29
34	3.87	3.55	0.32
35	2.66	2.39	0.27
36	4.12	2.73	1.39
37	4.32	3.98	0.34
38	4.31	2.90	1.41
39	4.26	2.66	1.6
40	4.2	2.63	1.57
41	4.03	2.66	1.37
42	4.04	3.50	0.54
43	3.85	2.43	1.42

Well No.	Average Depth of water level (m) during 2018	Average Depth of water level (m) during 2019	Fluctuations in depth (m) in 2019 w. r. to 2018
44	4.16	3.26	0.9
45	3.42	3.00	0.42
46	3.57	3.12	0.45
47	4.26	2.75	1.51
48	3.95	2.00	1.95
49	3.68	2.90	0.78
50	4.02	3.70	0.32
51	3.84	2.94	0.9
Average	**3.73**	**2.81**	**0.92**

Table 2 : Yearly average depths of water levels in the wells (m)

Average Depth of water levels in wells (m) during 2016	Average Depth of water levels in wells (m) during 2017	Average Depth of water levels in wells (m) during 2018	Average Depth of water levels in wells (m) during 2019
6.25	4.07	3.73	2.81

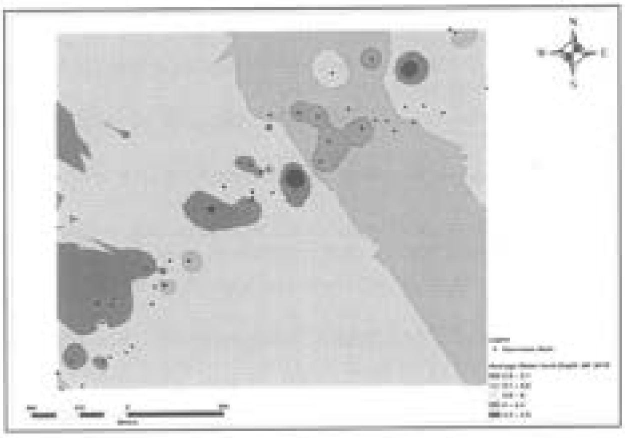

Fig 2 : Average Depth of water level (m) during 2018

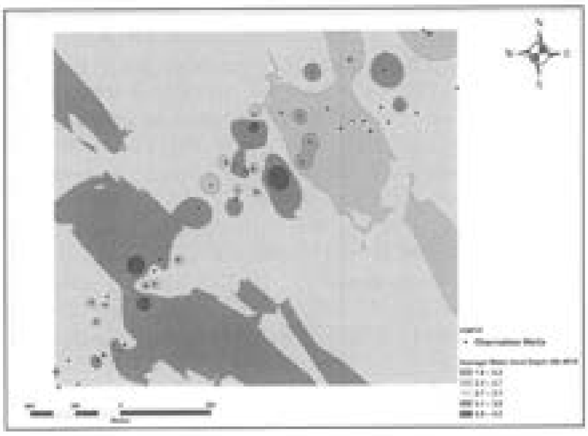

Fig 3 : Average Depth of water level (m) during 2019

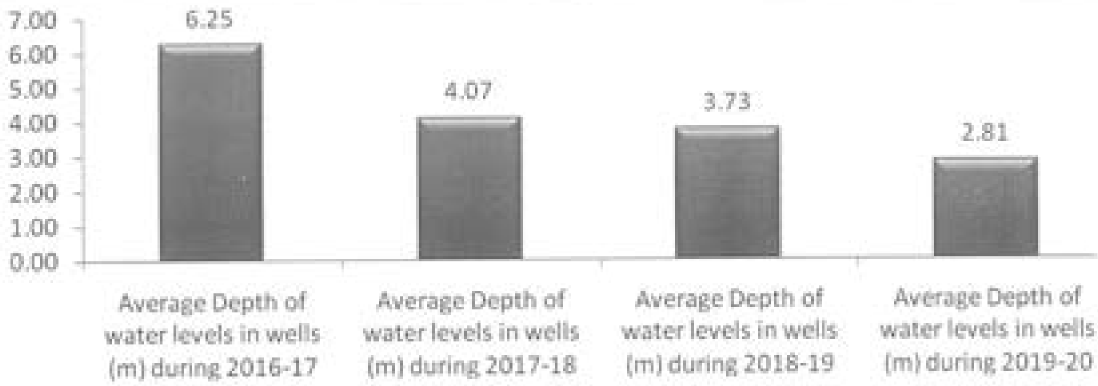

Fig. 4 : Yearly average depth of water levels in the wells (m)

The year wise increase in average well water depths as compared to the project implementation year are given in (Table 3) and it was observed that the increase in well water levels was by 2.18m, 2.52m and 3.44m respectively during 2017, 2018 and 2019 over the year 2016.

Table 3 : Year wise increase in average water levels in the wells over 2016-17 (initial year)

Increase over the year 2016		
During year 2017	During year 2018	During year 2019
2.18m	2.52m	3.44m

Based on the observed data it was inferred that the average groundwater levels in the 51 wells during the year 2019 was increased by 3.44m as compared to the groundwater levels of the initial year 2016 and the increase was by 0.92m as compared to the year 2018 as shown in Fig. 4.

Summary and Conclusion

The recharged water in the wells was utilized for protective irrigations to different crops. Increase in yield of different crops has been noticed. Also the area under irrigation was also observed to be increased.

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Technological Gap in Adoption of PDKV Recommended Soil Reclamation Practices in Purna Valley of Vidarbha

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Abstract: The study was purposively conducted in Akola district of Maharashtra state. Exploratory research design was used for the study. A purposive sample of 120 farmers from villages in Akot and Akola talukas from Akola district was drawn and the data was collected with the help of structured interview schedule. The findings indicated that, more than half of the respondents (57.50%) had medium level of knowledge of PDKV recommended soil reclamation practices. It was observed that, majority (55.83%) of the respondents were medium category of overall technological gap of recommended PDKV soil reclamation practices, followed by 44.17 per cent of respondents were observed in high level of technological gap. As regards existence of technological gap in green manuring with Dhaincha / Sun hemp be undertaken for amelioration of salt affected soil, it may be due to lack of knowledge about green manuring crops. In case of recommended passing the alkali water through gypsum bed having 30 cm thickness before irrigation to avoid its deleterious effect on soil property, it may be due to lack of knowledge to extend technological gap. The selected characteristics of farmers *viz*., education, occupation, annual income, source of information, extension contact, innovativeness, risk orientation, economic motivation and knowledge were negatively but significantly correlated with the technological gap at 0.01 level of probability and scientific orientation were negatively but significantly correlated with the technological gap at 0.05 level of probability. Whereas, age and land holding is non-significantly associated with overall technological gap.

Keywords: Technological gap, Adoption, Knowledge, PDKV recommended soil reclamation practices, Purna valley

Introduction

Soil, water, air and sunlight are the basic natural resources. Soil is one of the most important of them. It could have been impossible for us to stand, live and eat if there was no soil, but a much smaller number of people realizes a great national importance of conserving and careful utilization of the greatest gift of god. Soil degradation in India is estimated to be occurring on 147 million hectares (Mha) of land, including 94 Mha from water erosion, 16 Mha from acidification, 14 Mha from flooding, 9 Mha from wind erosion, 6 Mha salinity, and 7 Mha from combination of factors. The salinity / sodification is a chemical deteriotion mainly observed in semi-arid region due to unscientific use of irrigation channels and decrease in the level of ground water. It may also be due geological reasoning, especially observed in Purna valley of Vidarbha region (Sagare *et al*., 2000). The major problem of degradation in Maharashtra is because of water erosion, which may be ascribed to erratic and high intensity rainfall, undulating and sloping land and also ill drained nature of soil. Salt affected soils of Purna valley are developed on basaltic alluvium under arid and semi-arid conditions. The Purna valley of Vidarbha region is an east-west elongated basin with slight covering to south occupying the part of Amravati, Akola, Buldhana districts of Vidarbha and extends from 20° 45' to 21° 15' N latitude and 75° 25' to 77° 45' E longitude with east-west length of 100-150 km having width of about 10 to 60 km covering an area of about 4.69 lakh hectares distributed in Amravati (1738 sq. km), Akola (1939 sq. km) and Buldhana (1015 sq. km). The salts have varing degree of deterioration i.e. salinity or sodicity (Anonymous, 2010).

The Purna valley spreads on both sides of Purna river affecting about 892 villages, covering an area about 4692 sq.km. Purna river initiates from southern slopes of Gavilgad hills Satpuda range which the principal drain is joining to Tapi river. The major tributaries are Pedhi, Sarapi, Shahanur, Katepurna, Uma, Morna, Man Mas, Nirguna, Nalganga, and Dyanganga. The soils are formed from basaltic alluvium and are characterized by high clay content (50-70%), alkaline in reaction, calcareous with slow permeability possess to soil degradation. Salinity of ground water is historical phenomenon in Purna track. The precipitation of calcium in the form of carbonate immobilizes calcium and magnesium in the valley soils and dominancy of sodium is increased which deadly affects physical and chemical properties of soil. Under such situation, it may enhance clay dispersion, destabilization of soil structure and decaking of soil capillary network which ultimately affect water transmission characteristics. The Purna valley soil have severe limitations for their sustainable use owing to the development of adverse physical condition especially poor internal drainage system at 5 ESP and therefore the farmers are not in position to maintain sustainable crop production under rained situation and cannot irrigate these soils even with good quality of irrigation water. With this background the present study was planned and carried out with the specific objectives as follows:

1. To find out the technological gap in adoption of PDKV recommended soil reclamation practices among the farmers in Purna valley
2. To study the relationship between selected characteristics of farmers and technological gap

Methodology

The exploratory research design of social research was used and the present study was conducted in Akola district in Vidarbha region of Maharashtra state. From the Akola district, out of seven talukas the maximum area under saline-sodic tract is found in Akola and Akot talukas. Therefore these two talukas were purposively selected. The list of villages selected for present study is Ugawa, Hingna (Tamaswadi), Ganghigram, Gopalkhed, Nirat, Chohatta bajar, Deoli, Vani, Rel and Kutasa. From each selected villages of the two talukas, 12 respondents were selected by simple random sampling procedure. Thus the sample from each taluka was 60 and making a total sample of 120 respondents for the present study. The PDKV recommendation made to these practices have been considered as full level of adoption and the practices actually adopted by the farmers were considered as farmers level of adoption. Then, the gap for each practice was calculated by deducting the farmers level of adoption from full level of adoption. In the present study, technological gap was operationalized on the decision in adoption of selected PDKV recommended soil reclamation practices by the farmer and expressed in percentage.

The technological gap index for each practice was work out by using following formula.

$$\text{Technological gap index} = \frac{R - A}{R} \times 100$$

Where, R = Maximum obtainable score of adoption of PDKV recommended soil reclamation practices.

A = Actual obtained score of adoption of PDKV recommended soil reclamation practices.

The respondents were categorized into three categories, i.e. low, medium and high on the basis of overall technological gap index of the equal interval method as low (Up to 33.33), medium (33.34 to 66.66) and high (Above 66.66) level of adoption of PDKV recommended soil reclamation practices.

Results and Discussion

I. Knowledge about PDKV recommended soil reclamation practices

The cent percent of the respondents had knowledge about deep ploughing at every year or alternate years is necessary to increase the permeability of soil and to reduce surface runoff and losses of soil nutrients, followed by 77.50 per cent of the respondents knowledge about Incorporation of gypsum @ 50% G.R. i.e. 2.5 t/ha in combination of FYM 5 tones is necessary to increase productivity, 76.67 per cent of the respondents knowledge about cultivate the salt tolerant crops at suitable spacing with application of gypsum and FYM, 65.83 per cent of the respondents knowledge about major and micro nutrients should be applied on the basis of soil test analysis, 58.33 per cent of the respondents knowledge about the integrated application of 2.5 t FYM + 1.25 t gypsum per ha. in tied broad bed furrow after 15-20 days of sowing is recommended for improvement in soil property, yield and monetary returns of soybean in deep black sodic soil of Purna valley of Vidarbha and provision of farm ponds in a micro watershed should be made to conserve the excess water and to reduce the salinity or sodicity from the adjacent area, 44.17 per cent of the respondents knowledge about planting the salt tolerant trees the pits (60X60X60) at the suitable spacing should be excavated and should be filled with gypsum @ 3 kg and FYM @ 10 kg/pit. and surface soil, 25.83 per cent of the respondents knowledge about deep furrows after 2 or 3 rows of crops should be opened after 30 days of sowing to enhance efficiency of amendments and fertilizers, 20.00 per cent of the respondents knowledge about field boundaries should be demarcated with vetiver bunds or the strip of natural grass so that damaging velocity of runoff water can be reduced, and very low knowledge about to pass the alkali water through gypsum bed having 30 cm thickness before irrigation to avoid its deleterious effect on soil property and green manuring with Dhaincha / Sun hemp be undertaken for amelioration of salt affected soil had 03.33 per cent and only 01.67 per cent knowledge of the respondents, respectively.

Table 1: Distribution of respondents according to their knowledge

Sl. No.	Knowledge Index	Respondents (n=120)	
		Frequency	Percentage
1	Low (Up to 33.33)	26	21.67
2	Medium (33.34 to 66.66)	69	57.50
3	High (Above 66.66)	25	20.83
	Total	**120**	**100.00**

It is observed from Table 1 that, majority (57.50%) of the respondents were medium level of knowledge, followed by 21.67 per cent of the respondents were low level of knowledge and 20.83 per cent of the respondents were high level of knowledge about PDKV recommended soil reclamation practices.

II. Technological gap in PDKV recommended soil reclamation practices

The effort have been made to find out distribution of respondents based on their level of existing technological gap about PDKV recommended soil reclamation practices are presented in Table 2.

Table 2: Distribution of the respondents according to practice wise technological gap in PDKV recommended soil reclamation practices

Sl. No.	PDKV recommended soil reclamation practices	Technological gap (%)
1	Deep ploughing at every year or alternate years is necessary to increase the permeability of soil and to reduce surface runoff and losses of soil nutrients.	12.08
2	Incorporation of Gypsum @ 50% G.R. i.e. 2.5 t/ha in combination of FYM 5 tones is necessary to increase productivity.	46.66
3	Major and micro nutrients should be applied on the basis of soil test analysis	70.83
4	Application of Zinc sulphate 10-50 kg depending on the zinc status of soil.	81.25
5	Deep furrows after 2 or 3 rows of crops should be opened after 30 days of sowing to enhance efficiency of amendments and fertilizers	87.91
6	Provision of farm ponds in a micro watershed should be made to conserve the excess water and to reduce the salinity or sodicity from the adjacent area.	80.83
7	The field boundaries should be demarcated with Vetiver bunds or the strip of natural grass so that damaging velocity of runoff water can be reduced.	88.75
8	Cultivate the salt tolerant crops at suitable spacing with application of gypsum and FYM.	49.16
9	It is recommended to pass the alkali water through gypsum bed having 30 cm thickness before irrigation to avoid its deleterious effect on soil property.	99.16
10	While planting the salt tolerant trees the pits (60X60X60) at the suitable spacing should be excavated and should be filled with gypsum @ 3 kg and FYM @ 10 kg/pit. and surface soil.	74.58
11	Green manuring with Dhaincha / Sun hemp be undertaken for amelioration of salt affected soil.	100.00
12	The integrated application of 2.5 t FYM + 1.25 t gypsum per ha. in tied broad bed furrow after 15-20 days of sowing is recommended for improvement in soil property, yield and monetary returns of soybean in deep black sodic soil of Purna valley of Vidarbha.	65.41

It is observed from Table 2 that, cent percent of the respondents had technological gap regarding in green manuring with Dhaincha / Sun hemp be undertaken for amelioration of salt affected soil, followed by 99.16 per cent of the respondents found technological gap in recommended to pass the alkali water through gypsum bed having 30 cm thickness before irrigation to avoid its deleterious effect on soil property, 88.75 per cent of the respondents found technological gap in the field boundaries should be demarcated with vetiver bunds or the strip of natural grass so that damaging velocity of runoff water can be reduced, 87.91 per cent of the respondents found technological gap in deep furrows after 2 or 3 rows of crops should be opened after 30 days of sowing to enhance efficiency of amendments and fertilizers, 81.25 per cent of the respondents found technological gap in application of zinc sulphate 10-50 kg depending on the zinc status of soil, 80.83 per cent of the respondents found technological gap in provision of farm ponds in a micro watershed should be made to conserve the excess water and to reduce the salinity or sodicity from the adjacent area, 74.58 per cent of the respondents found technological gap in while planting the salt tolerant trees the pits (60X60X60) at the suitable spacing should be excavated and should be filled with gypsum @ 3 kg and FYM @ 10 kg/pit.

and surface soil, 70.83 per cent of the respondents found technological gap in major and micro nutrients should be applied on the basis of soil test analysis, 65.41 per cent of the respondents found technological gap in the integrated application of 2.5 t FYM + 1.25 t gypsum per ha. in tied broad bed furrow after 15-20 days of sowing is recommended for improvement in soil property, yield and monetary returns of soybean in deep black sodic soil of Purna valley of Vidarbha, 49.16 per cent of the respondents found technological gap in cultivate the salt tolerant crops at suitable spacing with application of gypsum and FYM, 46.66 per cent of the respondents found technological gap in incorporation of gypsum @ 50% G.R. i.e. 2.5 t/ha in combination of FYM 5 tones is necessary to increase productivity and 12.08 per cent of the respondents found technological gap in deep ploughing at every year or alternate years is necessary to increase the permeability of soil and to reduce surface runoff and losses of soil nutrients.

It is concluded from the findings that, low technological gap found in deep ploughing at every year or alternate years is necessary to increase the permeability of soil and to reduce surface runoff and losses of soil nutrients and very high technological gap found in green manuring with Dhaincha / Sun hemp be undertaken for amelioration of salt affected soil due to lack of knowledge about green manuring crops.

Table 3: Distribution of respondents according to overall technological gap

Sl. No.	Technological gap Index	Respondents (n=120)	
		Frequency	Percentage
1	Low (Up to 33.33)	00	00.00
2	Medium (33.34 to 66.66)	67	55.83
3	High (Above 66.66)	53	44.17
	Total	**120**	**100.00**

It is observed from Table 4 that, 55.83 per cent of the respondents were medium level of technological gap, followed by 44.17 per cent of the respondents were observed in high level of technological gap. None of the respondents were observed under low level of technological gap. A similar finding was reported by Chinchmalatpure et al. (2011).

III. Coefficient of Correlation of selected characteristics of respondents with their technological gap

The correlation coefficient of technological gap with personal, socio-economic, situational, communication and psychological characteristics of the respondents have been depicted in Table 4.

It is seen from Table 4 that, among selected variables education, annual income, occupation, source of information, extension contact, innovativeness, risk orientation, economic motivation and knowledge were negatively but significantly correlated with technological gap at 0.01 level of probability and scientific orientation negatively but significantly correlated with technological gap at 0.05 level of probability. Therefore the null hypothesis was rejected, for these characteristics shows that there exist significant relationships with technological gap of PDKV recommended soil reclamation practices. The variable age shows positively non-significant relation with technological gap and land holding shows negatively non-significant relation with technological gap.

Table 4: Coefficient of correlation of selected characteristics of respondents with their technological gap

Sl. No.	Variables	'r' value
1	Age	0.0120 ^{NS}
2	Education	-0.4558**
3	Land holding	-0.1348 ^{NS}
4	Annual income	-0.3161**
5	Occupation	-0.2813**
6	Source of information	-0.3183**
7	Extension contact	-0.2904**
8	Innovativeness	-0.2848**
9	Risk orientation	-0.3954**
10	Scientific orientation	-0.2121*
11	Economic motivation	-0.3725**
12	Knowledge	-0.7785**

Similar findings were also reported by Chetana Konde, (2017), Chinchmalatpure et al. (2011), Khambatkar (2018), Noorjehan and Hanif (2014) and Yogita Wankhede et al. (2016).

Conclusion

From the above findings it can be concluded that, 57.50 per cent of the respondents had medium level of knowledge of PDKV recommended soil reclamation practices. It was observed that, majority (55.83%) of the respondents were medium category of overall technological gap of recommended PDKV soil reclamation practices. Cent percent of the respondents had technological gap regarding in green manuring with Dhaincha / Sun hemp be undertaken for amelioration of salt affected soil, followed by 99.16 per cent of the respondents found technological gap in recommended to pass the alkali water through gypsum bed having 30 cm thickness before irrigation to avoid its deleterious effect on soil property, 88.75 per cent of the respondents found technological gap in the field boundaries should be demarcated with vetiver bunds or the strip of natural grass so that damaging velocity of runoff water can be reduced. It was observed that, majority of the respondents faced constraints in adoption of PDKV recommended soil reclamation practices like lack of knowledge about green manuring (98.33%), followed by lack of knowledge about to pass the alkali water through gypsum bed before irrigation (96.66%), unavailability of gypsum (77.50%). It was also observed that most of the farmers do not have knowledge about green manuring crops so the study implied that, farmers will have to increase contact with Agricultural University and KVK Scientists and participate in different agricultural exhibition time to time and try to increase the knowledge about green manuring crops which will help them to maintain the soil health. The technological gap among the farmer was medium to high, hence the extension agencies and development organizations should organize different extension programmes in the village, like demonstration, campaign, training programme etc. so that the farmers will help in increasing their knowledge and adoption about soil reclamation practices.

The selected characteristics of farmers *viz*., education, occupation, annual income, source of information, extension contact, innovativeness, risk orientation, economic motivation and knowledge were negatively but significantly correlated with the technological gap at 0.01 level of probability and scientific orientation were negatively but significantly correlated with the technological gap at 0.05 level of probability. Whereas, age and land holding is non-significantly associated with overall technological gap.

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Ergonomic Assessment of Pedal and Hand Mode of Maize Shelling Operation

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Abstract: Maize is the most important cereal grain in the world and India stands sixth in terms of production with 2.4 % to the total world maize production from 8.5 million hectare with 5 % share in world harvested area. Traditionally, de-husking and shelling of maize are carried out manually which involves lot of drudgery. The grains were detached from dried de-husked cob by manual or mechanical devices. This operation is highly labour intensive and involves more drudgery in addition to losses of grain in terms of quantity and quality. Octagonal / tubular maize sheller, hand maize sheller, power-operated maize sheller and commercial power-operated threshers are available , but somewhere the tubular maize sheller and hand maize shellers preferred by marginal and small farmers at domestic level only. . In such case human power are still the major contributors of energy requirement for production of agriculture. To overcome the problems, ergonomical evaluation of hand equipment is needed to reduce fatigue and to increase efficiency and thus ergonomic assessment of hand operated rotary maize sheller was carried out.

It was evident from experiment that the output capacity of maize sheller was 141 kg h^{-1}in hand cranking mode which increased to 220 kg h^{-1} when the maize sheller was operated in pedal mode results in 36% increase in output capacity. Shelling efficiency of maize sheller was almost similar in hand cranking (98.19 %) and in pedalling (98.09%) modes of operation respectively. combination of selected independent parameter during the evaluation of pedal mechanism.

It was evident from the study that heart rate during operation of maize sheller in hand cranking mode (154.3 beats min^{-1}) was about 52 beats min^{-1} higher than heart rate during pedalling mode of operation. If we compare increase in heart rate, there was an increase of about 47.1 beats min^{-1} in hand cranking mode as comparing to pedalling mode of operation. The corresponding oxygen consumption rate was calculated as 1.17 l $min^{-1}$and 0.34 l min^{-1} for hand cranking mode and pedalling mode respectively. In pedalling mode of operation oxygen consumption rate was observed 70.94% lower as compare to hand cranking mode.

Maize is the most important cereal grain in the world, after wheat and rice, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries. The World's maize production is estimated about 96.80 crore tonnes in 2015-16 as per the (International Grain Council report of September, 2015) which is 3.5 % less than last year. In India, the area under maize is estimated about 76.60 lakh ha in Kharif season of 2015-16 which is 2.28 % less than last year (78.39 lakh ha), (Anonymous, 2002). India stands sixth in terms of production with 2.4 % to the total world maize production from 8.5 million hectare with 5 % share in world harvested area. In India, maize mostly grown in all the states and it is one of the most important staple foods. According to the survey of an existing practices of maize shelling, it was observed that different methods for cob shelling are used in the country, Traditionally four methods are used for shelling the cob grain by hand (1) using the thumb, (2) rubbing two cobs against one another, (3) rubbing a cob against rough course and (4) beating the cobs using a bamboo or wooden sticks. These procedures of maize shelling are energy and labour intensive operation. The maize shelling has been improved by the use of tubular maize shellers and getting popularity among the small and marginal farmers at small scale (Agrawal and Satapathy, 2006).

After harvesting, cobs are plucked manually with the help of traditional sickle and cobs were dried in open yard for the reduction of moisture content up to 15 % to 21 % (d. b.). Traditionally, de-husking and shelling of maize are carried out manually which involves lot of drudgery. The grains were detached from dried de-husked cob by manual or mechanical devices; this detachment process is called shelling. When its output compared with the manual process, it reported to be 30 kg h^{-1} with shelling efficiency of 80 % and grain damage of 8.3 % (Akubuo, 2002). It was also reported that the per cent recovery of grain from maize cob in manual shelling is 78.4 % (Ali *et al.*,1986). Thus, this operation is highly labour intensive and involves more drudgery in addition to losses of grain in terms of quantity and quality.

The large land holding farmers use power operated maize dehusker- shellers for de-husking of cob becoming popular but these power operated maize dehusker-shellers are operated by 3.73 kW electric motor,7.46- 8.95 kW diesel engine, 9.7 kW power tiller and tractor. At the remote villages there is problem of electricity and also unavailability of repair and maintenance facility. In such case human power are still the major contributors of energy requirement for production of agriculture. For overcoming these problems ergonomical evaluation of hand equipment is needed to reduce fatigue and to increase efficiency.

Keeping the above factors in view, present study was under taken on ergonomic assessment of hand operated rotary maize sheller.

Review of Literature

Solanki et al. (2006) evaluated ergonomically a three types of hand operated maize shellers. The performance in respect of cardiac cost, overall tiredness, body part discomfort and output were evaluated. The heart rate while working with all maize shellers indicates moderate workload on the subjects. The overall discomfort score varied from 3.5 to 4 i.e. 'more than light discomfort' and body part discomfort score was 51 for all the maize shellers. The highest output was observed with maize sheller having serrated tins than other two maize shellers. The use of this maize sheller could help to reduce the drudgery by 18.75% and 45.13% than tubular and octagonal shaped maize shellers respectively having plain fins.

Singh (1977) developed a hand operated maize dehusker-sheller and ergonomically evaluated with ten farm women to assess the physiological workload and its performance in standing and sitting postures. Two workers are required during its operation, i.e., one for hand cranking and another for feeding the cob. One by one cob (without removing its outer layer/sheath) was fed in hopper at an interval of about 4s. Farm women operated the equipment at their rhythmic speed in both postures. The average heart rate of subject was 144 and 142 beats min^{-1} in standing and sitting postures, respectively. The overall discomfort rating (ODR) and body parts discomfort score (BPDS) clearly indicated that the standing posture could be better option for operation of the equipment. This was found to reduce the physiological cost by 38.95% and 21.62% in dehusking & shelling the maize cob with hand and dehusking by hand & shelling by octagonal maize sheller respectively.

Potdar Rahul Rajaram (2011) stated that ordinarily popular maize shellers are not capable of handling the un-dehusked cobs. Due to this reason hand or pedal operated equipment is needed. Keeping this in view, initial work on pedal operated maize dehusker-sheller was taken in 1980 at Udaipur. This machine was operated by one women workers. It also might require more energy during its operation due to use of rasp bar as dehusking element. This might be some of the reasons for not becoming popular in addition to human-machine relationship.

Materials and Methods

Performance evaluation of original hand operated rotary maize sheller was also carried out to evaluate shelling operation in terms of output capacity, shelling efficiency and un-threshed grain. The subject was advised to perform the maize shelling operation and the output was noted down. The methodology adopted was as follows.

i. The experiments were done on dry maize cobs.

ii. The maize shelling operation was carried out for 15 minutes.

iii. The shelled maize grains were collected in gunny bag and weighed. The output capacity was calculated as ratio of total grain at outlet to time required for shelling operation.

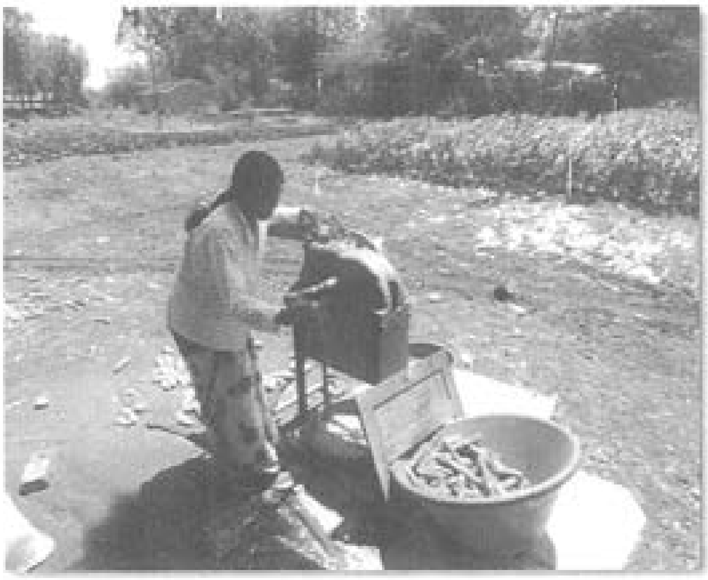

Plate 1 : Hand operated maize sheller

To evaluate the performance of pedal operated maize sheller ,the operators were given the tips, information and working of the machine for 20 min before starting the actual trials. In each trial machine was operated for 15 min to shell the maize cobs with moisture content of 12 to 18 %. The weight of detached kernels collected in the tray and from the collection unit, spread kernels, damaged kernels and completely shelled cob was recorded after each trial to determine shelling efficiency, total output capacity, percentage of unshelled grain and germination percentage.

Plate 2 : Pedal operated m,aize sheller

Physiological responses of the hand operated maize sheller

Physiological cost of operation is expressed in terms of heart rate and oxygen consumption rate.

Heart rate

The subjects were given a rest of 30 minutes prior to start of the experiment. Polar heart rate monitor (Polar Vantage NV) was used for continuous recording of heart rate data for each trial and the subject was asked to keep calm and quite while her heart rate data was recorded. The duration of each trial was 15 minutes. All precautions were observed while fitting the heart rate monitor as mentioned by the manufacturer. The watch of the monitor was fitted to the wrist of the subject and the chest belt having inbuilt electrodes was fitted on her chest.

During the hand cranking operation, heart rate was continuously recorded. It is considered that subject's heart rate gets stable after 3-5 minutes (Astrand and Rodahl, 1997). Therefore, for calculating mean working heart rate the heart rate data from 6^{th} to 15^{th} minutes of operation were used.

Oxygen consumption rate

Oxygen consumption rate is the more accurate variable for measuring the physiological workload but it is difficult to measure while performing the task. Hence, indirect method i.e. estimation of oxygen consumption using correlation between heart rate and oxygen consumption is used. Different equations are available to correlate heart rate and oxygen consumption rate. However in the present study the following equation proposed by (Anonymous, 2007b) was used.

$$Y = 0.0162\,X - 1.314$$

Where, Y = Oxygen consumption rate in l min^{-1}

X = Heart rate in beats min^{-1}

This equation has been suggested for female agricultural workers in the age group of 25 to 35 years.

Psychophysical responses

Psychophysical responses of operation are expressed in terms of overall discomfort rating .

Overall discomfort rating

For the assessment of overall discomfort rating a 10 – point Visual Analogue Discomfort (VAD) scale proposed by Legg and Mahanty (1985) was used . At the end of each trial subjects was asked to indicate their overall discomfort rating. Overall discomfort rating given by each of the subjects were added and averaged to get the mean rating.

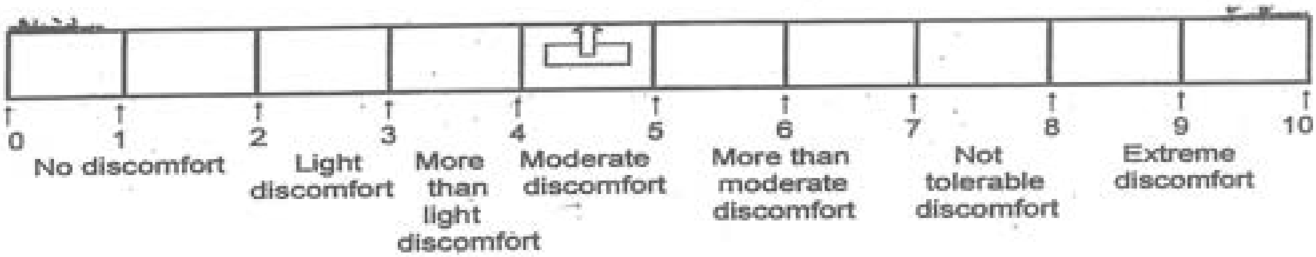

Fig 1 : Visual Analog Discomfort (VAD) scale for assessment of overall body discomfort rating

Result and Discussion

Ergonomical comparison of hand and pedal shelling operation

The physiological, psychophysical responses of the selected subject for the hand and pedal operated during shelling operation have been studied for the efficient work.

Table 1 : Paired t-test for difference of mean of performance parameters

Comparison	Output capacity, kg h^{-1}	Shelling efficiency, %
Hand (existing)	140.57	98.19
Pedal (modified)	219.68	98.09
Paired t-test	Highly significant	Non-significant

Significant at 1% level of significance

It was evident from Table 1 that the output capacity of maize sheller was 141 kg h^{-1}in hand cranking mode which increased to 220 kg h^{-1} when the maize sheller was operated in pedal mode. Thus, output capacity of maize sheller increased by 36%which might be due to increase in the speed (50-78 RPM) of maize sheller when operated in cycling mode.

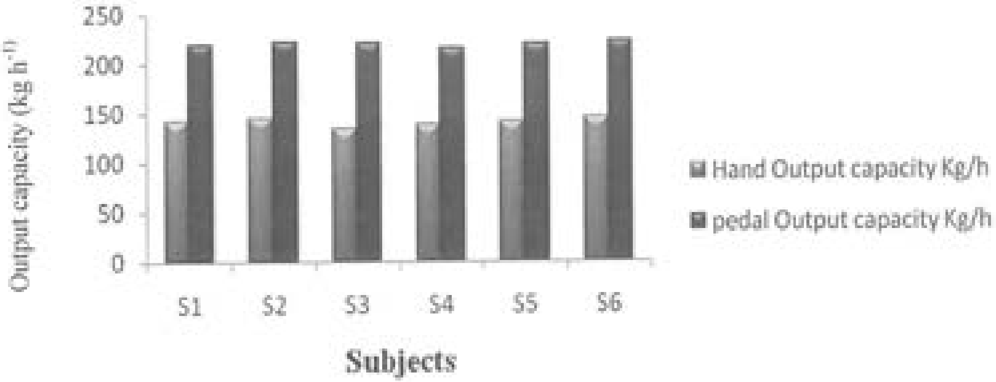

Fig. 2 : Output capacity in two different mode of operation

Statistical analysis using paired t-test indicated that there was a highly significant difference in output capacity of maize sheller in two modes of operation. Output capacity in pedalling mode of operation was significantly higher than hand cranking mode.

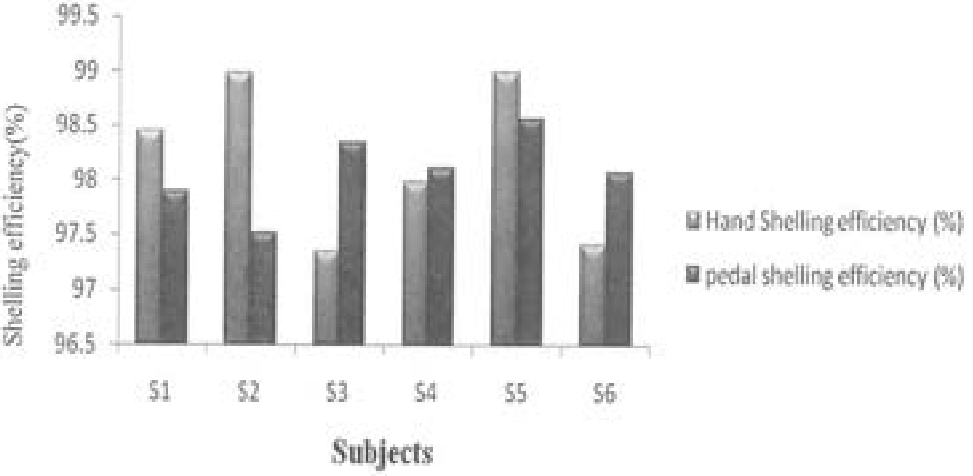

Fig. 3 : Shelling efficiency in two mode of operation

Shelling efficiency of maize sheller was almost similar in hand cranking (98.19 %) and in pedalling (98.09%) modes of operation respectively. (Ali *et al,* 1986) reported that the shelling efficiency of hand operated maize sheller as 93.5%, which was slightly lower in comparison to that reported in the present study. The lower shelling efficiency in the former case may be due to higher moisture content of 16.5 to 19 % (d.b.) at the time of shelling as compare to the moisture content of 9-11 % during this study. (Singh,1977) reported that percentage of unshelled kernels decreased the shelling efficiency and increased with the increase in speed. They also observed an increased in cob moisture content.

Statistical analysis of data using paired t-test indicated that the shelling efficiency of maize sheller in two modes of operation did not differ significantly. Table 1 presents the data for the effect of modes of operation on shelling efficiency of maize sheller, which indicates that effect of modes of operation on shelling efficiency, was non-significant.

No visible kernel damage was observed in both the operating modes at the low moisture content of kernels. Moreover, the operating speed of the machine was also low even in the pedalling mode of operation. (Singh,1977) reported an increase in kernel damage from 2 to 7% when the speed of operation of power operated maize sheller having peg type cylinder increased from 510-980 RPM and kernel moisture content increased from 7 to 17 % (w.b.).It was observed that at higher moisture content of the kernels became more deformable resulting in crushing of kernels before and after detachment from the cobs. However, with decrease in moisture content compressive strength of kernels increased which resulted in decreased kernels damage.

Performance of maize sheller during hand cranking and pedalling modes of operation

The output capacity of maize sheller increased when operated in pedalling mode using pedalling mechanism in comparison to that during hand cranking mode. The major reason for this increase in output capacity was the increased operating speed of pedal as compared to hand cranking mode. In pedalling mode of operation it was possible to operate the maize sheller at optimal speed of 78 rpm but in hand cranking mode the optimal speed of 78 rpm could not be achieved because higher operating speed in hand cranking mode caused more stress on the operator and also the operator was not able to synchronise the rate of feeding with that of higher operating speed.

Another reason for increased output capacity of maize sheller in pedalling mode of operation was the continuous and uniform feeding of cobs into the sheller. The person feeding the cob to shelling unit by using both hands. In doing so, subject use her right hand for picking the cobs and feeding it into the inlet of the machine. Sometimes subject had to push the cobs into the throat with another cob when forward movement of the cob was impeded while feeding a cob with diameter larger than the average diameter of cobs. Subject left hand was used for holding the cobs at place in the feeding trough. It was observed that when two or more cobs entered into the throat of the machine at a time, none of them got entry inside the machine. The operator had to remove all the cobs except one to let it go inside the machine. Thus, it was observed that the cobs must be put one after the other for easy entry of cobs into the machine.

On the other hand in the hand cranking mode of operation, the operator performed the hand cranking operation by his right hand and fed the cobs into the sheller by his left hand. In doing so she had to hold the cobs at place in the feeding trough to avoid them falling two or three at a time into throat; secondly she had to pick/guide the cobs s ide into throat of the machine one by one and thirdly she had to push the cobs into the throat of the machine using clutch in subject hand, if required. While doing all these activities simultaneously ones she concentrated on feeding the cob to maintain continuous feeding subject cranking speed reduced and when she tried to maintain the cranking speed the cob feeding became improper.

Physiological and psychophysical responses in hand cranking and pedalling modes of operation

The meaningful comparison of physiological responses during operation of maize sheller in two modes of operation, the increase in heart rates over resting values (ΔHR) were calculated. The data on increase in heart rate obtained for six female agricultural workers during operation of maize sheller in two modes of operation were subjected in statistical analysis to know the effect of two modes of operation on physiological responses.

Table 2 : Physiological and psychophysical responses during operation of rotary maize sheller in two modes of operation

Particulars	Physiological and psychophysical parameters		
	Hand	Pedal	
		Minimum value at best combination	Maximum value
Heart rate, beats min^{-1}	153.4	101.67	125
Increase in heart rate (ΔHR)over rest during, beats min^{-1}	74.6	27.5	51
Oxygen consumption rate, l min^{-1}	1.17	0.34	0.72
Average overall discomfort rating (ODR) on 10-point scale	6.77	2.88	4.36
Cardiac cost of operation , beats kg^{-1}	40.89	9.5	20.66

Table 3 : Paired t-test for mean of ergonomical evaluation.

Comparison	Working heart rate, beats min^{-1}	Increase in heart rate, beats min^{-1}	Body part discomfort score	Overall discomfort rating	Cardiac cost of operation, beats kg^{-1}	Energy expenditure rate, kJ min^{-1}
Hand operated maize sheller	153.4	74.6	29.5	6.77	40.89	24.4
Pedal operated maize sheller	101.67	27.5	7	2.88	9.5	8.81
Paired t-test	Highly significant	Highly significant	Highly significant	Highly significant	Highly significant	Highly significant

Significant at 1% level of significance

Overall discomfort rating (ODR) of the agricultural workers on 10- point visual analogue scale (VADS) was evaluated as psychophysical parameter. Table 2 presents the data on these parameters during the operation of maize sheller in both operating modes. The minimum value was observed at the best combination of the selected independent variable where the maximum value was obtained at any other combination of selected independent parameter during the evaluation of pedal mechanism.

It was evident from Table 2 that heart rate during operation of maize sheller in hand cranking mode (154.3 beats min^{-1}) was about 52 beats min^{-1} higher than heart rate during pedalling mode of operation. If we compare increase in heart rate, there was an increase of about 47.1beats min^{-1} in hand cranking mode as comparing to pedalling mode of operation. The corresponding oxygen consumption rate was calculated as 1.17 l $min^{-1}$and 0.34 l min^{-1} for hand cranking mode and pedalling mode respectively. In pedalling mode of operation oxygen consumption rate was observed 70.94%lower as compare to hand cranking mode.

Kumar and parvathi (1998) reported that average energy expenditure during operation of hand operated maize sheller was 25 kJ min^{-1},which was equivalent to an oxygen consumption rate of 1.2 l min^{-1}.This value of oxygen consumption rate was very close to that reported in the present study when the maize sheller was operated in hand cranking mode.

Table 3 showed the comparison by paired t-test for the effect of modes of operation on increase in heart rate. It indicates that mode of operation affected increase in heart rate significantly ($p<0.01$).The increase in heart rate in hand cranking mode was significantly higher ($p<0.01$) than that during pedalling mode.

The average overall discomfort rating during operation of maize sheller in hand cranking mode was three times 6.77 to that achieved during pedalling mode2.88.

Cardiac cost of operation in hand cranking mode was 40.89 beats kg^{-1} to that achieved during pedalling mode 9.5 beats kg^{-1}. It showed that the cardiac costs of operation during hand mode are highly more than pedal mode. From the above results, it may be concluded that the pedalling mode can be successfully act as an interface between the human worker and a hand operated maize sheller to operate the machine. In pedalling mode output of the machine increases with less effort and fatigue.

In order to see the effect of converting a hand operated maize sheller to pedal operated maize sheller on ergonomical parameters i.e. heart rate, work pulse, body-part discomfort score, overall discomfort rating cardiac cost of operation, energy expenditure rate and on performance parameters i.e output capacity, shelling efficiency, and percent of unshelled grain and its significant difference, the statistical analysis was done by using paired t-test for difference of means. All parameters are significant at 5% and 1% level, except shelling efficiency because they are similar in hand cranking and pedalling mode of operation.

On the other hand during the operation of maize sheller in hand cranking mode, the speed of the machine reduced substantially when a larger diameter cob passed through the machine. In that condition the torque required for rotating the crank increased and the operator had to exert more force to rotate the crank.

Further, in pedalling mode of operation the movement was only in the leg segments and the leg muscles performed the major activity in producing the required power. On the other hand, in cranking mode apart from the movements in the hand segments, activity in the trunk muscles was also present there for moving the body to and fro.

On the other hand, because of lower peak aerobic power achieved during arm exercise than that during leg exercise an absolute sub-maximal power output during an upper body exercise represents a higher relative intensity than in a lower body exercise (Pendergast, 1989). A higher physiological strain has been reported with time during arm exercise than during leg exercise at the same muscle group specific relative workload (Aminoff et al.,1998). Thus, it can be assumed that the acceptable physical workload expressed as the percentage of VO_{2max} for the corresponding muscle group should be lower during the arm exercise than during leg exercise.

Categorization of workload

According to classification suggested by Varghese (1994) pedal operated rotary maize sheller was categorized into "Light" workload and existing maize sheller in "unduly heavy" category. When considering the overall discomfort rating at sitting height (710 mm), pedal length (180 mm) and backrest height (400 mm), it was categorized in "light discomfort".

Table 4 : Categorization of workload

Categorization of workload			
Physiological parameter		**Hand operated maize sheller**	**Pedal operated maize sheller**
1	Heart rate, beats min^{-1}	Unduly heavy	Light
2	Oxygen consumption rate, lit min^{-1}	Unduly heavy	Light
Psychological parameter			
1	Overall discomfort score	More than moderate discomfort	Light discomfort
2	Energy expenditure rate, kJ min^{-1}	Unduly heavy	Moderate

Considering the acceptable limit of oxygen consumption rate of 0.81 l/min for continuous work as proposed by Saha *et al.*, (1979) and taking the value of oxygen consumption rate during the rest as 0.28 $lmin^{-1}$(mean value of resting oxygen consumption rate of subjects who participated in the present study), the acceptable limit of change in oxygen consumption rate for continuous work comes to 0.53 l min^{-1}. So according to Varghese, (1994)the oxygen consumption rate was in category of "light" workload and with considering energy expenditure rate it falls in "Moderate" category of workload.

Average overall discomfort rating during operation of maize sheller in hand cranking mode was almost two times (6.7) of that achieved during pedalling mode (2.88). According to Visual Analogue Discomfort scale the category of the pedal operated maize sheller found to be light discomfort where in hand operated, it was in category more than moderate discomfort. However, there is a need for the study of psychophysical responses for longer duration of work for better quantification of reduction in these responses during operation of maize sheller in pedalling mode of operation.

In pedal mode of operation, the human resource and the machine must combine as seamlessly for optimal performance. It was important to obtain a proper fit between the worker and the pedalling device so that the worker could perform optimally and the risk of developing an overuse injury was decreased. Saddle height was one of the aspect of the pedalling device that can affect both performance and injury Hamley and Thomas, (1967); Lawrence and de Vries,(1976); Nordeen – Snyder,(1977); Holmes *et al.* (1994); Peveler *et al.*,(2008).Saddle height is an important design parameter for a pedal mechanism, which affects on the performance of the worker during pedalling work. A lower saddle height may cause thigh injury due to compression of thigh muscles when the pedal is at its top most position. On the other hand higher saddle height may unnecessarily stretch the legs when the pedal is at bottom most position. The optimal saddle height would, therefore, be a compromise between the two extreme positions and causes minimal discomfort to the worker resulting in lower physiological and psychophysical responses.

Crank length is the sensitive variable which influences on the physiological cost during pedal operator (Gonzalez and Hull, 1988). The leverage of the bicycle drive train, also known as "gain ratio" depends on the crank length, size of both the sprockets and wheel diameter. For a stationary pedalling device this ratio entirely depends only on first two factors. A longer crank length requires lower force application to produce a given torque because of more leverage. However, it causes excessive knee flexion, which may lead to pain when the knee was flexed more than it was used. Simultaneously, the linear speed of the pedal at a given pedalling rate also increases with the increase in crank length. Furthermore the range of movement of skeletal members of limbs involved in pedalling also increases causing more stretching of muscles involved. Therefore, an optimal crank length would be one, which optimises the force application as well as the range of movement of the skeletal muscles. Since, the physiological responses during pedalling are a function of applied force as well as muscle elongation during pedalling; the optimal crank length would produce the minimum physiological responses.

Inbar *et al.* (1983) studied the optimal cycle crank length for eliciting maximal leg power output. The results indicated optimal crank length as 164 and 166 mm for maximum power. Optimal crank length was shown to depend on leg length. It was suggested that for homogeneous population, the conventional 175 mm crank length was close to the calculated optimum for power production and to optimized pedal length of 180 mm which was also close to the referred crank length.

However, a failure to adjust this factor to the anthropometric dimensions of heterogeneous populations might result in much greater fall- off in cycle short –term power performance. While seat-height variation affects only the force applications angles of muscles, crank length alteration with involving several other factors as well. Those factors include:

a) The attainable torque which increases with longer cranks.
b) The increasing muscle tension with decreasing crank length affecting muscle fatigue.
c) The changing muscular tension /contraction-velocity interrelationship and its effect on maximized the power.
d) The exponentially increasing kinetic energy loss in the moving leg mass with increasing crank length (greater range of angular displacement).
e) The changing pattern of the muscular force application angles which was moved away from the optimal with increasing crank length (grater range of angular displacement).

Since the behaviour of these factors was not parallel or even unidirectional, the precise nature of the combined effect was difficult to predict.

In-line the results of the present study, several earlier studies have reported that pedal length of 180 mm was optional from performance as well as power production point of view Too and landwer, (2000); Danny and Landwer,(2000) studied the effect of five pedal crank length viz.110,145,180,230 and 265 mm on hip, knee and ankle angles and on the peak, mean and minimum power production. The highest mean and peak powers occurred with a crank arm length of 180 mm. Similar findings have been reported by (Too and Landwar, 2000) and in present study. On the other hand, (Martin and Spirdusco, 2001) and (Martin *et al.*,2002) observed that though the cycling power as significantly affected by crank length, use of 170 mm long cranks did not substantially compromise maximum power in most results. However, one major limitation of their study was that they did not use any intermediate crank length between 170 to 195 mm.

The increase in output capacity with increase in operating speed of 78 RPM to 292 RPM given to shelling mechanism was mainly due to increased rate of kernel removal from the cobs. Beyond this speed the shelling capacity was mainly limited by the rate of feeding the cobs into the sheller. The operator was able to match the rate of cob feeding the cobs into the sheller up to 78 RPM. It was to mention here that the operator used his both hands for feeding the cobs unlike only one hand used for cob feeding during actual operation of the machine in hand cranking mode because the right hand was engaged for operating the machine by hand cranking.

When considering a torque require for operating the maize sheller decreased with increase in operating speed from 78 to onwards for all categories of maize cobs. Beyond the operating 78 RPM, it was almost constant with increase in operating speed. On the other hand, the operating torque decreased with decrease in diameter of maize cobs.

According to (Tiwari P.S. *et al.*,2010) On the basis of test results of simulation experiment on rotary maize sheller at different operating speeds, it may be concluded that the operating speed of maize sheller should be 70-80 RPM to get higher output capacity and shelling efficiency of the maize sheller and lower operating torque in comparison to other operating speeds.

The decrease in shelling capacity with increase in maximum diameter of maize cobs was mainly because the forward movement of the cobs inside the sheller was restricted with in maximum diameter of the cobs. Shelling capacity of maize sheller or cobs having maximum diameter <45 mm was highest because the cobs got through the machine very easily. Cobs having maximum diameter between 45 to 55 mm and >50 mm faced some difficulty in getting through the machine. Sometimes, the larger diameter cobs did come to complete stagnancy while the machine was still in operation and the operator had to push it inside the sheller with the help of another cob. It was to mention here that the clearance of the shelling plate with cob holder was kept constant during the tests for all sizes of maize cobs. Had the clearance increased for larger diameter cobs the shelling capacity might have been similar for different sizes of the maize cobs. However, further study at different clearance settings was required to arrive at any conclusion.

From the above discussions, it evidently emerge that the pedal mechanism can be successfully used as an interface between the human worker and a hand rotary type machine for getting more output from the machine with less effort and fatigue. Further studies with other low power rotary machines such as groundnut decorticator, grain mill, rotary type water pump etc, are required to quantify the improvement in performance of those machines and reduction in effort and fatigue due to operation of the machines in pedalling mode using pedal mechanism.

Conclusions

After assessing the ergonomical performance of pedal and hand operated Maize shelling operations, following conclusions were drawn.

1. The output capacity is increased from 140.57 kg/h to 219.68 kg/h when the mode of operation is changed from hand to pedal mode of operation.
2. The heart rate was reduced from 153.4 beats/min to 101.67 beats/min when the mode of operation is changed from hand to pedal mode of operation.
3. Oxygen consumption rate was also reduced from 1.17 l/min to 0.34 l/min when the operation of maize shelling was shifted to pedal mode from hand operated mode.
4. After changing the mode of operation, the overall discomfort rate was also reduced from 40.89 to 8.50.
5. The hand operated maize shelling operation was categorized in *unduly heavy* category while pedal mode of operation was observed in *moderate* category of workload.

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Mechanisum for Reducing Drudgery of Farm Womens

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Abstract: After harvesting Roselle from the plant, the calyses are separated/ detached manually, these Roselle calyses are then used for preparing different value added products e.g. sharbat, Jam, syrup, pickle, Roselle supari etc. the manual method is laborious and time consuming. With the increasing demand of calyces for preparing various value added products there was an urgent need to develop a detacher for calyces separation/ detaching from Roselle fruit and hence Roselle calyces detacher (RCD) was developed. The developed detacher consists of cutting blade, cutting blade holder, spring and rivet arrangement. The Detacher is a manual hand operated tool with wt. of 125 g and overall dimensions of 225 mm x 105mm x 20 mm .

The average percentage of calyces and seed capsule were found to be 50.64 (±2.726) and 49.36 (±2.726). The manual calyces detaching efficiency was observed to be 68.9 ± 4.51 % and by Roselle Calyces detacher (RCD) was observed to be 96.8 ± 1.23%. According to the the ergonomical observations it was observed that detaching of Roselle calyces falls under LIGHT WORKLOAD. It is recommended to use Roselle calyces detacher (RCD) for detaching calyces from Roselle fruit as the capacity of RCD is 5.62± 0.918 kg/h.

Introduction

Roselle *(Hibiscus sabdariffa L.)*, is a member of malvacae family and it is a tropical plant of considerable economic potential. Roselle is quite hardy and grows well in most soils that are deep, fairly fertile and Roselle is a drought-tolerant crop. Roselle grows well in a wide range of climates except in the super-humid zones. The crop is cultivated extensively at present in India, Thialand, Germany, Senegal and Egypt for its pleasant red coloured calyces which are used for making jam, jelly and bottle drinks (Omobuwajo et al. 2000). Production of Roselle in Maharashtra is 0.39 lakh bales grown on 26000 ha (Indian Agril., 2003). In Maharashtra it is grown under mixed cropping pattern and the use is limited to unleavened bread and chutney.

In India, Africa and Mexico, all above-ground parts of the roselle plant are valued in native medicine. In 1962, Sharaf confirmed the hypotensive activity of the calyces and found them antispasmodic, anthelmintic and antibacterial. Three years later, Sharaf and co-workers showed that both the aqueous extract and the coloring matter of the calyces can be used for Mycobacterium tuberculosis.

After harvesting Roselle from the plant, the calyses are separated manually, these Roselle calyses are then used for preparing different value added products e.g. sharbat, Jam, syrup, pickle, Roselle supari etc. There are two traditional methods by which the calyces are detached from the Roselle plant i) Dried roselle calyces are obtained either by harvesting the fruits fresh, decore them, and then dry the calyces; or the other way is by ii) leaving the fruits to dry on the plants to some extent, harvest the dried fruits, dry them further if necessary, and then separate the calyces from the capsules. Both the methods are laborious and time consuming. Thus, with the increasing demand of calyces for preparing various value added products there is an urgent need to develop a detacher for calyces separation from Roselle plant.

Objectives

- To develop a detacher for Roselle calyces.
- Testing and evaluation of Roselle calyces detacher (RCD) for detaching Roselle calyces from Roselle fruit.

Materials and Methods

A) Physical and mechanical properties of Roselle fruit

The Roselle fruits used for the study were obtained from local market of Akola district. The good healthy matured Roselle fruits were selected for the study. The 25 fruits were randomly selected for determination of physical properties. The measurements were carried out with three replications.

Different physical properties of Roselle fruit (RF) and Roselle Seed Capsule (RSC) were determined by standard methods viz. length, width, thickness, geometric mean diameter, roundness, sphericity, surface area and moisture content. The volume, bulk density, true density and porosity of Roselle seed capsule (RSC) was determined.

B) Development of Detacher and calculation of Detaching Efficiency :

(i) Observations with respect to efficiency of detacher for fresh calyces is calculated by the expression (Balasubramaniam et al. 1993)

$$\text{Detaching Efficiency, DE (\%)} = \frac{W_T - W_D}{W_T} \times 100 \qquad (2.1)$$

where, DE (%) = Detaching efficiency, %

W_T = Total weight of Roselle fruits, kg

W_D = Weight of damaged calyces, kg

C) Ergonomical observations

The ergonomical observations with respect to psychophysical response such as overall discomfort rating (ODR), body part discomfort (BPDS), heart rate, pulse rate and energy expenditure of operator while operating Roselle calyces detacher were taken. I) Test Conditions II) Body weight and height of the subject III) Measurement of Heart Rate IV) Energy Expenditure V) Classification of workload VI) BPDS

Plate 1 : Female labour detaching with Roselle Calyces Detacher

Results and Discussion

The Physical properties of Roselle fruits (RF) and Roselle seed capsule (RSC) are summarized in the Table 2.4. The avg. length of Roselle fruit (RF) and Roselle seed capsule (RSC) calyces was 43.01 mm and 21.51 mm respectively. The avg. width of RF and RSC was 18.03 mm and 14.12 mm respectively. And the avg. thickness of RF and RSC was16.06 mm and 12.98 mm respectively. The avg. weight of RF and RSC was 8.27 gm and 3.33 gm respectively. The avg. moisture content of RF and RSC was 76.20 (% wb) and 22.8 (% wb) respectively. The geometric mean diameter of RF and RSC was 23.18 mm and 15.80 mm respectively. Also the sphericity for RF and RSC was 53% and 73% respectively.

The surface area covered by Roselle fruit and Roselle seed capsule was calculated as 1838 mm^2 and 1002 mm^2. The volume for Roselle seed capsule (RSC) was 6.31cm^3. The solid density of the RSC was calculated to be 1.208 g/cc. It shows that RSC was more compact and dense .The bulk density of the fruit was found to be 0.809 g/cc. The surface area for RF and RSC was found to be 1838 mm2 and 1002 mm2 respectively. This might be because of the larger size of the Roselle fruit (RF) and smaller size of Roselle seed capsule (RSC).

Since we are interested to develop a device for detaching calyces from seed capsule attached with epicalyx of fruit , the average diameter at this particular point was measured and found to be 13.58± 1.012 mm.Therefore the length of opening of both jaws was kept 16 mm.

After harvesting Roselle fruit from plants, the operation of calyces detachment from Roselle fruit was carried out manually. This operation of detaching becomes a laborious job and hence considering the design parameters the Roselle calyces detacher was developed which helps in detaching the calyces from Roselle fruit.

The developed Roselle calyces detacher is shown in Plate 1. A special stainless steel (SS -304) cutting blades made for the purpose of detaching calyces from seed capsule attached with epicalyx were welded firmly to upper and lower jaw (blade holder). The jaws were riveted to mild steel handle. A spring arrangement was given at the point of rivet to keep the handle in released position and allows the cutting blades to be at a distance of 16 mm. The sharp edge of cutting blade was sufficient enough to produce cutting force more than 4 kg at the point where calyces are joined to seed capsule attached with epicalyx. Thus, Roselle calyces can be detached and held in one hand and epicalyces with seed capsule can be detached with the help of Roselle calyces detacher by the other hand.

The Roselle fruits were harvested from the STRU, Dr. PDKV, Akola field and brought to AICRP on PHTS lab. The erogonmical observations were taken at the temp of 25.6°C and 35% humidity. Five female labours were selected for study and their weight and height was measured. The subjects (preferably those who participated in the physiological cost trials) were involved in this test. Each trial was conducted for two hour duration. During the two hour duration subject was not allowed for any rest as such. The subjects in Table 1 were selected to perform detaching of Roselle calyces by manual method as well as by using Roselle calyces detacher.

Table 1 : List of Subjects/ female farmers used for ergonomical study

Sr No.	Code No.	Name of Subject
1	F	Sau. Savita More
2	G	Sau. Pushpa Chavan
3	H	Sau. Anita Sukdane
4	I	Sau. Varsha Phukat
5	J	Sau. Manda Dahatonde

The weight and height of the subjects were measured and the Body Mass Index (BMI) for female subject (Table 2) was measured as per caterorised presumptive diagnosis.

Table 2 : BMI of the female subject

Subject	Age, yrs	Weight ,kg	Height, m	BMI	Category	Limits, yrs
F	49	60	1.625	22.718	mesomorph	20-25
G	28	51	1.524	21.958	mesomorph	20-25
H	41	57	1.651	20.91	mesomorph	20-25
I	35	49	1.575	19.758	ectomorph	< 20
J	38	58	1.600	22.650	mesomorph	20-25

Table 2 shows the presumptive diagnosis of female subjects as mesomorph and ectomorph i.e these subjects are normal and low weight (normal) and hence can perform the psychophysical work of detaching Roselle calyces.

Roselle calyces detaching was carried out manually and also with Roselle Calyces detacher with the help of five female subjects subjects as mentioned above and the performance for both (M & RCD) was studied with three replications as shown in Table 3.

It was observed from Table 3 that the average working heart rate for manual Roselle calyces detaching was 95 ± 6.279 beats/min and with RCD it was 94.8 ± 6.603 beats/min respectively. It was observed that the average work pulse(ΔHR) for manual Roselle calyces detaching was 11.33 ± 3.416 beats/min and for RCD it was 10.86 ± 2.774 beats/min respectively. The average energy expenditure for manual Roselle calyces detaching was 6.385 ± 0.998 kJ/min and for RCD it was 6.353 ± 1.050

kJ/min respectively. The output/capacity for manual Roselle calyces detaching was 0.95 ± 0.187 kg/hr and for RCD it was 5.37 ± 0.541 kg/hr respectively.

Table 2.3 : Performance of manual detaching and detaching with Roselle Calyces detacher (Female subject) :

Sr No	Name of Subject	Replications	Heart Rate (beats/min.) Rest		Working		Work Pulse (ΔHR)		Energy Expenditure (kJ/min)		Output (kg/h)		Category of work load on the basis of Heart Rate Data	
			M	RCD	M	RCD	M	RCD	M	RCD	M	RCD	M	RCD
1.	"F"	R1	81	81	89	88	8	7	5.431	5.272	0.980	4.200	Light workload	Light workload
		R2	83	82	88	88	5	6	5.272	5.272	0.880	4.850		
		R3	81	80	89	88	8	8	5.431	5.272	0.800	4.765		
2.	"G"	R1	94	96	107	106	13	10	8.293	8.134	0.870	5.800		
		R2	95	94	105	106	10	12	7.975	8.134	0.900	5.900		
		R3	97	92	104	104	7	12	7.816	7.816	1.000	5.360		
3.	"H"	R1	84	87	95	99	11	12	6.385	7.021	1.200	5.800		
		R2	82	84	96	97	14	13	6.544	6.703	1.400	6.000		
		R3	84	85	98	99	14	14	6.862	7.021	1.000	6.100		
4.	"I"	R1	81	80	95	92	14	12	6.385	5.908	0.800	4.900		
		R2	85	82	96	90	11	8	6.544	5.590	1.100	5.200		
		R3	81	84	94	94	13	10	6.226	6.226	1.000	5.600		
5	"J"	R1	79	79	89	89	10	10	5.431	5.431	0.600	5.200		
		R2	74	74	92	90	18	16	5.908	5.590	0.850	5.100		
		R3	74	79	88	92	14	13	5.272	5.908	0.910	5.700		
Avg			**83.67**	**83.93**	**95**	**94.8**	**11.33**	**10.86**	**6.385**	**6.353**	**0.95**	**5.37**		
SD(±)			**6.842**	**6.076**	**6.279**	**6.603**	**3.416**	**2.774**	**0.998**	**1.050**	**0.187**	**0.541**		

M – Manual detaching of Roselle Calyces

RCD – Roselle calyces detacher for detaching of Roselle Calyces

Thus from Table 3 given by Varghese *et al.*, (1994) the category of work load is falling under LIGHT WORKLOAD on the basis of energy expenditure (5.1-7.5 kJ/min) and heart rate data (91-105 beats/min).

Also, the psychophysical responses of female subject by performing the detaching operation manually and with Roselle Calyces Detacher was observed from Overall discomfort rating (ODR) and Body part discomfort score (BPDS) and is given in table 4.

Table 4 : Psychophysical response of the female subject by performing the detaching operation manually and with Roselle Calyces Detacher :

Sr. No.	Name of Subject	Replications	Overall Discomfort rating		Mean rating (ODR)		Body part discomfort score		Mean rating (BPDS)	
			M	RCD	M	RCD	M	RCD	M	RCD
1.	"F"	R1	3.8	2.6	4.0	2.6	20	10	19	11
		R2	4.1	2.5			19	11		
		R3	4.2	2.7			18	12		
2.	"G"	R1	3.5	1.5	3.7	1.2	18	12	19.7	11
		R2	3.7	1.0			21	10		
		R3	3.9	1.2			20	11		

Sr. No.	Name of Subject	Replications	Overall Discomfort rating		Mean rating (ODR)		Body part discomfort score		Mean rating (BPDS)	
3.	"H"	R1	3.1	2.2	3.4	2.2	20	11	21	11.7
		R2	3.5	2.5			21	13		
		R3	3.6	2.0			22	11		
4.	"I"	R1	3.7	1.5	3.8	2.0	19	12	19.3	12
		R2	3.9	2.4			20	13		
		R3	3.9	2.2			19	11		
5.	"J"	R1	3.8	2.1	3.9	2.1	20	13	19	12
		R2	4.0	2.2			18	11		
		R3	3.9	2.0			19	12		
AVG			**3.77**	**2.04**	**3.76**	**2.02**	**19.6**	**11.53**	**19.6**	**11.54**
SD (±)			**0.273**	**0.518**	**0.230**	**0.511**	**1.183**	**0.990**	**0.834**	**0.508**

Thus, for Overall discomfort rating (ODR) it was observed that in case of manual detaching, the operator faces more than light discomfort is 3.76 ± 0.230 (i.e. VADS range 3-4) and while working with Roselle calyces detacher the operator faces light discomfort is 2.02 ± 0.511 (i.e. VADS range 2-3). For, Body part discomfort score (BPDS) it was observed that, the operator has more Body part discomfort score (BPDS) while working manually (19.6 ± 0.834) as compared to working with Roselle calyces detacher (11.54 ± 0.508).

Conclusions

- The average weight of calyces and seed capsule were found to be 506.44 g (±27.26) and 493.55 g (±27.26). And the average percentage of calyces and seed capsule were found to be 50.64% (±2.726) and 49.36% (±2.726).
- The capacity of Roselle calyces detacher was found to be 5.62± 0.918 kg/h, which was five time more than manual detaching capacity (i.e.0.96 ±0.275 kg/h).
- The efficiency of Roselle Calyces detacher (RCD) for detaching calyces from Roselle fruit was observed to be 96.8 ± 1.23% whereas manual detaching efficiency was observed to be 68.9 ± 4.51 %.
- Detaching calyces by Roselle Calyces Detacher is falling under LIGHT WORKLOAD on the basis of energy expenditure (5.1-7.5 kJ/min) and heart rate data (91-105 beats/min).
- The Overall Discomfort rating (ODR) for manual operation was 3.54 ± 0.321 (i.e. VADS range 3-4) which was reduced comparatively by Roselle calyces detacher i.e 2.14 ± 0.404 (i.e. VADS range 2-3).
- The Body part discomfort score (BPDS) while working manually was 19.8 ± 1.356 which was reduced comparatively by Roselle calyces detacher (12.16 ± 1.089).

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Contrast Performance and evaluation between Power Operated Cylindrical and Fly wheel Chaff-Cutter Machine

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Abstract: Chaff cutter is a straw or fodder cutting machine which is used in uniform cutting of the fodder for the animals or row material for agro industries. The chaff played a vital role in most agricultural production.Day by day increasing the energy demand, unemployment and time management in developing countries like India.The experiment has been carried out for the performance and comparison of chaff fodder or cutter energized bythe electric power. The chaff cuter machines are used every day by farmers in India for preparation of fodder for the livestock they own. This paper discus about the comparison performance and evaluation between poweroperated Cylindrical and Fly wheel chaff-cutter machine.

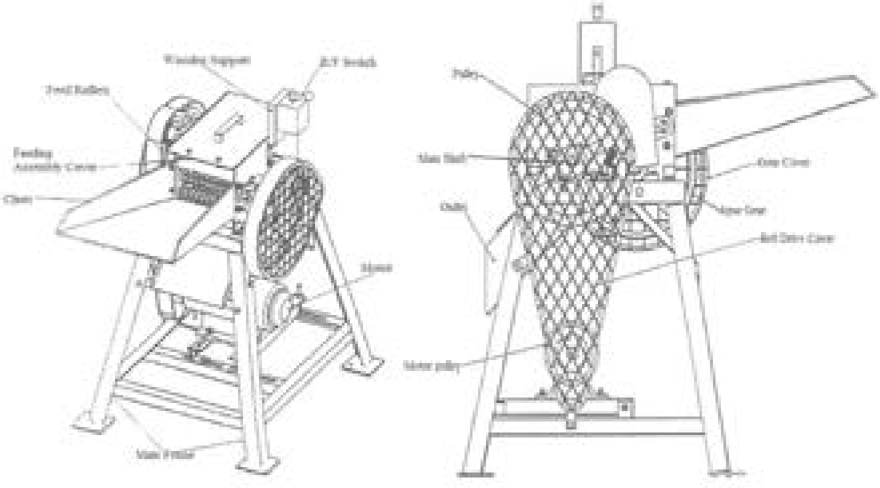
Keywords: Chaff cutter, Power operated, Cylindrical, Flywheel,Fodder

Introduction

Nutrition is the foundation of a livestock production system and proper nutrition is imperative for achieving highand sustained livestock productivity. The success of animal reproduction and health programme rests on proper nutrition.The cutting of crop resides into small pieces then feeding to the cattle, increases the consumption and palatability offeed, hence reducing the wastage.Animal feeding is very important aspect of livestock husbandry. It is very necessary to have effective utilizationof available feed sources. Chaff is hay cut into small pieces for feeding to livestock (Mohan and Kumar, 2004); it is agood fodder, and at its best is cleanly and evenly cut, free of dust, of good colour and with a fresh aroma. Chaff can bepurchased from commercial chaff cutting mills (Wikipedia, 2009). Cutting chaff can be done by manually operatedmachine and electric operated one, As far as cutting by manually operated machine is concerned. Traditionally for theoperator it is done manually which is physically demanding through it energy and postural requirements and is commonlyregarded as source of drudgery (Kumar *et al.*, 2004); many farmers associated with this task reported back, shoulderand wrist discomfort. It may also cause clinical or anatomical disorders and may affect worker's health. By consideringthe above constraints in chaff cutting machine it is necessary to introduce the power operated chaff cutter looking tothe shortage of labour, drudgery involved in manually operated chaff cutter operation. By keeping above facts in to theconsideration present investigation has been made an attempt to study the performance evaluation of power operatedchaff cutter.

Materials and Methods

Cylindrical chaff-cutter



Fly wheel chaff-cutter

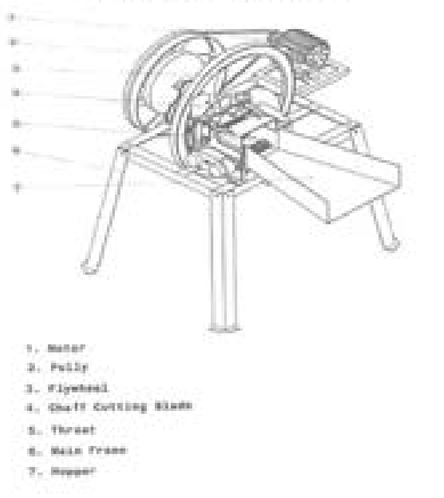


Fig. A: Various view of chaff cutter

The power operated Cylindrical and Fly wheel chaff-cutter evaluated for the assessment the performance at Department of Farm Power and Machinery, Dr. PanjabraoDeshmukhKrishiVidyapeeth, Akola. The details functional components of chaff cutter arechaff cutters assemblies, power transmission, fly wheel, blades, shear plate, feeding assembly, feed rollers, feedingmechanism and stand. The Various view of chaff cutters are shown in Fig. A. Details specification of power operated Cylindrical and Fly wheel chaff-cutterare given in Table A.

Table A. : Details specification of power operated Cylindrical and Fly wheel chaff-cutter

Details specification of power operated Cylindrical and Fly wheel chaff-cutter			
	Constructional details	**Cylindrical chaff-cutter**	**Fly wheel chaff-cutter**
1.	**Stand, mm**	It is made up of MS angle of size 50x50x5in trapezoidal shape platform supported by four legs having length 695; MS flatis provided on their lower ends.	It is made up of MS angle of size 60x60x5: 75x75x3; in rectangular shape platform supported by four legs with holes provided on their lower ends.
	Size of platform, mm	Top 460 x 340 , Bottom 665 x 525	1200x960
	Height of platform from ground level , mm	730	835
2.	**Chaff Cutter Assembly**		
3.	**Power Unit**		
	Type & rating	Three Phase, AC induction motor, 3hp, 1440 rpm (CML No. 7162364)	Three Phase, AC induction motor, 3hp, 1430 rpm
	Switch	Reverse and forward Mounting on wooden flat support of size 105 x 150 x 22 mm.	Not Provided
	Method of mounting	Mounted on the M.S. angle 40 x 40 x 5 platform stand with the help of four nuts and bolts size 3/8"x1.5" fitted in the slot to adjust the belt tension.	Mounted on the M.S. platform stand with the help of four nuts and bolts size 3/8"x1" fitted in the slot to adjust the belt tension
	Recommended power, kW	2.2	2.2
	Size of mounting base, mm	530 x 435	415x215
	Mass , kg	32.1	37
4.	**Main Power Transmission**		
	Type	V belt and Pulley	V belt and Pulley
	Size of motor pulley, mm	90ϕ	Outer 98.15 ϕ, inner 25.66 ϕ
	Size of main shaft pulley, mm	305 ϕ	630 ϕ (thickness-6.15 mm)
	Type & size of belt	V belt, B1516Lp/B58 (double belt)	V belt, B-102 (double belt)
	Reduction ratio	1:0.295	1:0.15
	Arrangement for belt tensioning	Through the slot provided on the motor mounting base	Through the slot provided on the motor mounting base
5.	**Cutter Head**		
	Type	Cylindrical	Fly wheel
	Number	One	One
	Material	Mild Steel	Cast Iron
	Size of cylinder/Fly wheel, mm	210 x 180	830ϕ x 7
	Size of throat, mm	214	210
	Size of MS flat/'S' shape for mountingblade, mm	185x 45 x 11(For each blade)	500 (curved length)x 135 x 2.50
	No. & size of holes on MS flat/'S' shape for mounting blade, mm	3 & 11.3 ϕ (For each blade)	3 & 11.60 ϕ (For each blade)
	Size of main shaft bearings	UCP 207-20 (2 Nos.)	
	Method of mounting	Welded to main shaft through pedestal bearings at both end.	Welded to main shaft through pedestal bearings at both end.

Details specification of power operated Cylindrical and Fly wheel chaff-cutter			
	Constructional details	**Cylindrical chaff-cutter**	**Fly wheel chaff-cutter**
6.	**Blades**		
	Type	Straight &Rotating	Curved
	Number of blades	3 (Two rotating and one fixed)	3 (Two rotating and one fixed)
	Material of blades	High Carbon Steel	High Carbon Steel
	Dimension of blade, mm	222x 48 x 8 (Rotating blades) & 230x47x 8.2(Fixed Blade)	420 x 142 x 2.5
	Length of bevel edge, mm	14 (Rotating blades) & 10 (Fixed Blade)	10
	Method of mounting **Chapter 5** of this reportMethod of mounting	Each blade is mounted on MS flat of the rotating cylinder by three nut and bolts of size 3/8" x 0.55" and 3/8" x 1.5".	Each blade is mounted on as 'S' shaped sitting of flywheel by three nut and bolts of size 3/8", (sunk headed)
7.	**Shear plate (fixed edge)**		
	Number	One	One
	Material	Cast Iron	Cast Iron
	Size, mm	330x50x11	230x74x 17.50 (length x width x thickness)
	Method of mounting	Welded to feeding assembly at top of main frame.	Bolted to side covers of feeding assembly by four nuts and bolts.
	Recommended clearance between fixed & rotating blades, mm	Not recommended	Not recommended
	Method of clearance adjustment	By tightening /loosening the three bolts of size 3/8" x 1.5" provided for blade,	By tightening /loosening the six bolts of size 3/8" x 1" provided for each blade
8.	**Feeding Assembly**		
9.	**Main Shaft**		
	Material	Mild steel	Cast Iron
	Dimensions, mm	455 x 38 ϕ	855 x 15.10 ϕ
	Number & type of bearings	Two & ball bearings	Three& ball bearings
	Method of mounting	The main shaft is supported by two ball bearings with pedestal. The cylinder is locked in middle over shaft by welding and its rear end is connected to spur gear.	The main shaft is supported by three ball bearings and front end, middle of shaft is threaded and flywheel locked over it by one hexagonal nut size 22.35 mm. The flywheel is locked over shaft and its rear end is connected to pinion.
	Method of lubrication	A grease hole is provided on the each bearing cover	One grease hole is provided on the each bearing cover
10.	**Transmission System**		
	Type	Spur Gear	Warm and pinion gear
	Material	Cast Iron	Cast Iron
	Number of gear	2	3
	Number of teeth on each gear	14 &110	11
	Pitch, mm	5.8 & 5.1	27
	Depth of teeth, mm	6.8 & 5.6	15
	Method of power transmission	It takes drive from main shaft and transmits it to the feed roller.	It takes drive from flywheel of main shaft and transmits it in right angle to the feed roller.
	Method of lubrication	Semi solid lubrication (Grease)	Semi solid lubrication (Grease)

Details specification of power operated Cylindrical and Fly wheel chaff-cutter			
	Constructional details	**Cylindrical chaff-cutter**	**Fly wheel chaff-cutter**
11.	**Feed Rollers**		
	Number of rollers	Two	Three
	Type	Toothed	Toothed
	Material	Cast Iron	Cast Iron
	Length & diameter of roller, mm	225 x 75 ϕ (both upper and lower)	232 and 61.50 ϕ (upper) & 230 x 61.50 ϕ (Lower)
	Effective length of roller, mm	200(both upper and lower)	195 (upper): 215 (Lower)
	No. of teeth on each roller & their configuration	88 (8x 11 rows) (upper) &80 (8x 10 rows) (lower)	88(8x11 rows) (upper) & 96 (8x12 rows) (lower)
	Type of teeth & pitch, mm	Triangular and 10	Triangular and31.5
	Size of roller shaft, mm	380 x25ϕ (upper) &420 x 25ϕ (lower)	350x25x 25 (upper) & 350x25x25(lower)
	No. & type of shaft bearing	Two&Bushpedestal type	Two, bushes (for each shaft) fixed on support plate.
	Size of pedestal, mm	25.5 ϕ ID x 50 ϕ OD	24.5 ϕ x 360mm (upper) & 24.5 ϕ x 350mm (lower)
	Provision for Lubrication	Grease cup is provided	Provided
	Space between the axis of upper & lower roller shaft, mm		
	Minimum	80	100
	Maximum	125	160
	Method of space adjustment	Automatic spring loaded arrangement provided at the upper roller	Automatic spring loaded arrangement provided at the upper roller
	Speed of feeding rollers corresponding to 1440 rpm of the prime-mover, rpm	54	22
12.	**Feeding Mechanism**		
	Type of feeding	Manual, Chute feed	Manual, Chute feed
	Material	MS Sheet, 16 gauge (thick-1.63)	MS Sheet, 18 gauge(thick-1.3mm)
	Size of feeding trough, mm	922 x 230/408 (front/rear)x125/70(front/rear) (Length x Width x Depth)	750 x 330/245 (front/rear)x130/90(front/rear) (Length x Width x Depth)
	Height from ground level, mm	955at rear end and 790 at front end	950 at rear end and 940 at front end
	Length of covered portion, mm	212	Not provided
	Angle of inclination	70°	85°
	Method of mounting	The feeding chute is bolted to the inside covers of feeding assembly with nut and bolts	The feeding chute is bolted to the inside covers of feeding assembly with nut and bolts
	Safety Arrangements	Cover provided at the cutting mechanism and two grills are provided around side of the transmission for belt drive and gear drive.	One grill provided at the cutting mechanism and another around side of the transmission only no top cover is provided on the feeding chute.
	Transport arrangements	Not provided	Not provided
	Overall Dimensions, mm		
	Length	1455	1550
	Width	650	1320
	Height	1150	1460
	Mass With prime-mover	129	215

Performance test

Chaff cutter was tested at no load and on load condition while these test following methodology followed for theassessment of the performance of the power chaff cutter. For the evaluation of the performance of the chaff cutterdifferent test codes referred such as IS: 11459-1985, IS: 7897-1975 and IS: 15542: 2005.

Test at no load conditions

Power consumption: The chaff cutter was fixing on firmly on level and preferably hard surface. Then set the clearance betweenrotating and fixed blade and made other adjustments for proper working of the chaff cutter. After proper functioningof the chaff cutter was attach to an electric motor as shown in the circuit diagram given in Fig. B. The attachment ofcutter head with motor done by connecting the motor with the help of flat or V-belt and pulleys with the main axle ofthe cutter head. The allowances for V-belt drive losses was taken as 8 per cent as per the IS: 7897 (1975).

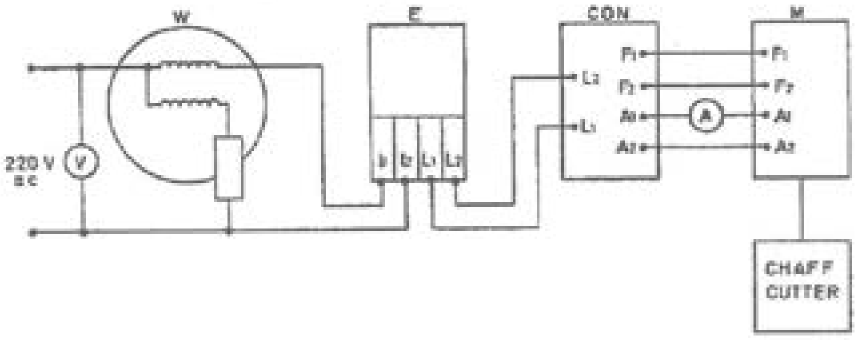


Fig. B: Circuit diagram

V = Voltmeter, 0-300 V, ac moving iron type

E = Energymeter, 3 ampere, single phase, 1600 rev/kWh

W = Wattmeter, 0-230 V, Single phase, dynamometer type

CON= 1.5 kW Speed Controller

M = dc motor shunt wound, 1.5 kW, 220 V

A = Ammeter, 0-10 A

After making of proper connection the motor coupled with chaff cutter and run for about 30 minutes. Then the following parameter was recorded.

– Resistance of the winding of the motor (R ohms),

– Initial reading of the energy meter (El watt-hour),

– Final reading of the energy meter (E2 watt-hour), and

– Time of run (T1minutes).

Then the total power at no load condition (P1) was calculated by the following formula.

$$P = \frac{60(E2 - E1)}{1000\ T1} \text{kW}$$

E2 = final reading of the energymeter, watthour

E1 = initial reading of the energymeter, watthour

T1 = time of run, min

Visual observations

During and after completing power consumption test the observations were recorded and as given in Table 4.

Test at load condition

Short run tests: The Chaff cutter was installed as given above procedure. The sufficient quantity of fodder was taken to be cut from the same variety of crop free from roots. The length of the fodder was selected as far as possible be of the same size. The moisture content of the fodder should be, as far as possible to be in the range of 75 to 85 per cent. The fodder was piled near the feeding tray in bundle formation. The mass of the bundles for continuous feeding was calculated by following formula

$$W3 = 4 \times D$$

where,

W3 = mass of the bundle in g, and

D = effective width of the feed roller in mm

Then the chaff cuter operated the cutter head at the speed specified and feed the fodder manually ensure that the feeding is done continuously and covers full width and height of the throat. The feeding was done from root side of the fodder. While feeding, rigid plastic pipe of diameter approximately equal to the diameter of the fodder stalk and 2 meters in length was fed along with the fodder. The duration of the operation was taken for more than 1 hour. The starting and stopping time was recorded carefully. The starting time was noted when the fodder comes in contact with feed rolls.

Parameters taken in consideration of the chaff cutter performance and calculated by the following formulae.

Quality of cut

Better quality of cut means least deviation of measured length of cut from the theoretical length of cut. But practically there would be some deviation because of feed interference. For getting proper measured length 25 cut pieces selected of plastic pipes and then measure the length of each piece and calculate the quality of work by the following formulae:

$$Q = (1 - \sigma)$$

where,

Q = quality of work and

σ = standared deviation of length of cut

$$\sigma = \sqrt{\sum_{i=1}^{n} \frac{(xt - x)}{n - 1}}$$

where,

n = number of pieces plastic pipes taken,

xt= measured length of cut pieces in mm

x = theoretical length of cut in mm and

i = serial number of cut pieces, (1,2,3............n)

$$x = \frac{\pi Di - N1}{NR}$$

Where,

Di = diameter of feed rolls in mm

N1= rev/min of feed rolls

N = rev/min of flywheel or cutter head, and

R = mumber of blads used

Quantity of cut

For calculating the quantity of fodder cut per hour of operation by using of the following formula:

$$W4 = \frac{60A}{T}$$

where,

W4 = quantity of cut in kg/h,

A = measured the quantity of cut in kg in T min

T = duration of operation in min

Power requirement

The power requirement of the chaff cutter was calculated by the following formulae giving due allowances to thetype of drive

$$P2 = \frac{60(E4-E3)}{1000T}$$

where,

P2 = total power consumed at load in kW

E4 = final reading of the energymeter in watthour

E3 = initial reading of the energymeter in watthour

T = duration of operations in min

P3 = P2 -P1

where,

P3 = power consumed by chaff cutter in kW

P2 = total power consumed at load in kW

P1 = total power consumed at no load in kW

Quantity per unit energy consumed

To calculate the quantity of cut in per kilowatt hour energy consumed (WS) the following formula was used.

$$W5 = \frac{W4}{P2}$$

Corrected quantity of cut

To avoid the variation of moisture content of fodder and the length of cut, the quantity of cut shall be corrected at 0 per cent moisture and 20 mm length of cut by the following formula:

$$W6 = \left[\frac{W4\,(100-M)}{100}\right]\frac{20}{L}$$

where,

W6 = corrected quantity of cut in kg/h,

W4 = quantity of cut in kg/h,

M = observed moisture per cent and

L = measured length of cut in mm

$$W7 = \frac{W6}{P3}$$

where,

W7 = corrected quantity of cut in kg/kWh

Performance index

For comparison of performance of the chaff cutter, calculate the performance index (PI) by the following formula:

$$PI = \frac{(W4 \times Q)}{P3}$$

where,

W4 = quantity of cut in kg/h,

Q = quantity of work,

P3 = power consumed by chaff cutter in kW

Results

The power operated chaff cutters were evaluated for their measurement performance at Deptt. of Farm Power and Machinery, Dr. PDKV, Akola. The test trials has been carried out at Dairy and Animal husbandry Department, Dr. PDKV, Akola.

Performance test

There were four trials were conducted out of which two trials on dry sorghum and two on ginni grass for both chaff cutters. The details physical parameter of sorghum crop and ginni grass are shown in Table 2.As well as the wear of blades shown in Table 3.

Short run Test at no load

The chaff cutter was operated for 1.0 hour at No Load and recorded the power consumption and visual observations.The details visual parameters shown in Table 4.and the power consumption at no load for flywheel and cylindrical type chaff cutters were recorded as 0.93and 0.45 kWh respectively.

Table 2 : Performance test

Sr. No.	Parameters	Cylindrical chaff-cutter				Fly wheel chaff-cutter			
		TEST TRIALS				TEST TRIALS			
		I	II	III	IV	I	II	III	IV
1.	Name of the crop	Sorghum		Ginni		Sorghum		Ginni	
2.	Moisture content of fodder, %	18.38	19.1	61.48	61.81	22.00	19.37	33.95	32.84
3.	Avg. length of stalk, cm	163.72	168.24	154.83	152.47	244.5	248.7	258.75	264.52
4.	Avg. dia. of stalks, mm	14.23	13.88	8.51	8.63	11.4	10.04	6.8	8.84
5.	Duration of test, h	5.25	5.5	5.75	4.8	5.25	5.50	5.30	5.75
6.	Feed rate, kg/h	412.7	401.3	914.8	935.4	210.65	208.54	281.48	292.83
7.	Quantity of cut, kg/h	410.2	398.6	910.4	930.2	205.95	203.04	275.8	288.46
8.	Quality of cut	0.75				0.79			
9.	Range of length fodder pieces, mm	10.85-18.2	11.23-17.9	11.4-19.35	10.28-19.9	7.5-12.3	5.6 -15	5-15	5.8-12.8
10.	Avg. length of fodder pieces, mm	14.6	14.23	14.86	14.88	10.06	10.4	9.20	7.86
11.	Variation in length of plastic cut pieces, %	4.68				3.21			
12.	Power consumed by chaff cutter ,kW	1.44	1.37	1.23	1.32	0.76	0.74	0.79	0.82
13.	Qty. of cut per unit energy consumed, kg/kWh	284.86	290.95	740.16	704.70	270.99	274.38	349.11	351.78
14.	Corrected quantity of cut, kg/h	458.32	453.22	459.61	455.73	319.37	314.83	396.01	492.95
15.	Corrected quality of cut, kg/kWh	318.28	330.82	373.67	345.25	420.22	425.44	501.28	601.16
16.	Performance Index	213.65	218.21	555.12	528.52	211.37	218.68	278.94	281.42

Table 3 : Wear of chaff cutter blade on mass basis

For Cylindrical chaff cutter				
Blade	Initial wt. (g)	Final wt. after 21.3 h of test (g)	Wear (%)	Wear per h (%)
B-1	589.45	581.35	1.37	0.065
B-2	536.15	531.45	0.88	0.041
For Fly wheel chaff-cutter				
Blade	Initial wt.(g)	Final wt. after 25h of test (g)	% wear	Wear rate h (%)
B-1	916.45	908.15	0.90	0.036
B-2	915.81	907.31	0.93	0.037

Table 4 : Visual observations during the chaff cutter was operated for 1.0 hour at NoLoad

Sr. No.	Parameters	Observations	
		Cylindrical chaff cutter	Fly wheel chaff-cutter
(a)	Presence of any marked oscillation during operation	Not found	Oscillation foundduring operation
(b)	Presence of knocking or rattling sound	Not found	Not found
(c)	Frequent slippage of belts	Not found	Not found
(d)	Smooth running of shaft/shafts in their respective bearings	Not found	Not found
(e)	Any marked unusual wear or slackness in any component	Not found	Not found
(f)	Any marked rise in bearing temperature	Not found	Not found
(g)	Stability of Chaff Cutter	Satisfactory	Not Satisfactory
(h)	Other observations	Not noticed	Not noticed

Cylindrical Chaff Cutter & Fly Wheel Chaff-Cutter

Quantity of work

- The average feed rate was observed as 407 kg/hr and 209.59kg/hr for Sorghum crop and 925.10kg/h and 287.15 kg/hrfor Ginni crop forCylindrical chaff cutter & Fly wheel chaff-cutter respectively.
- Average quantity of cut was observed 404.40kg/hr and 204.49kg/hr for Sorghum crop and 920.30kg/h and 282.13 kg/hrfor Ginni cropforCylindrical chaff cutter & Fly wheel chaff-cutter respectively.
- The average quantity of cut per unit energy consumed was found to be287.91kg/kWh and 272.68g/kWhfor Sorghum crop and 722.43 kg/kWh and 350.44kg/kWhfor Ginni cropforCylindrical chaff cutter & Fly wheel chaff-cutter respectively.

Quality of cut

- The quality of cut was determined from the deviation of measured length of plastic pipe cut 0.75 and 0.79 forCylindrical chaff cutter & Fly wheel chaff-cutter respectively.

Theoretical Length of Cut

- The theoretical length of cut was observed14.99 mm and 9.53 mmforCylindrical chaff cutter & Fly wheel chaff-cutter respectively.

Power Requirement

The average power consumed by chaff cutter was measured at a time of load test and found that1.41 kW and 0.75 kW for Sorghum crop and 1.28 kW and 0.81 kWfor Ginni cropforCylindrical chaff cutter & Fly wheel chaff-cutter respectively.

Corrected Quantity of Cut

a) The Corrected Quantity of Cut per hour455.77 and 457.67 kg/h for Sorghum crop and Ginni cropforcylindrical chaff cutter &317.1 and 444.48 kg/h for Sorghum crop and Ginni cropforFly wheel chaff-cutterrespectively.

b) The Corrected Quality of Cut per kW hour324.55 and 359.46 kg/kWh for Sorghum crop and Ginni cropforcylindrical chaff cutter &422.83 and 551.22kg/kWh for Sorghum crop and Ginni cropforFly wheel chaff-cutter respectively.

Long Run Test

The Cylindrical &Fly wheel chaff-cuttermachines were operated for total duration of 21.30 hr and 21.8 hr respectively, during the operation of chaff cutter, no breakdown in the cutter head, feeding mechanism, transmission system and other part of both chaff cutterswere noticed.

Labor Requirement

For both cylindrical and flywheel type chaff cutter machine two labours are required for operation of chaff cutter, one for feeding a fodder crop and one for handling cut materials.

Conclusion

It is conclude that feed rate,quantity of cut quantity of cut per unit energy consumed, power requirementand Performance Indexwas higher incylindrical typethan fly wheel typePower Operated Chaff-Cutter Machine for the both crop sorghum and ginni.

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Impediment in Adoption of Dry land Technologies

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Abstract: Maharashtra state has highest proportion of rainfed areas among the states. Agriculture in Vidarbha region is also characterized by rainfed farming, the dry land agriculture. In dry lands the annual rainfall is about 750 mm to 1500 mm but its distribution throughout the year is not uniform. Due to lack of improved scientific knowledge the yield potential per unit area is increasing one but the profit is not found satisfactory as compare to its adoptions. Therefore to ascertain, these facts the present study entitled constraints faced by the farmer in adoption of dry land technologies was undertaken with the objective to study the constraints faced by farmers in adoption of dry land technologies. The study was conducted in the Akola and Akot tahsil of Akola district of Maharashtra. From the selected village 12 farmers from each village were selected randomly. Thus in all 120 farmers were selected for the present study. The findings reported that majority of the farmers faced the constraints in adoption of dry land technologies such as uncertainty of weather (89.16%), non availability of rain water at proper time (85.83%), inadequacy of capital (84.16%), non availability of labours (79.16%) and dry seeding in cotton is not possible due to uncertainty of rains and soil type (black cotton soil) (71.66%). For overcoming the above constraints different interventions like organizing exposure visits, demonstrations, trainings etc. were organized to the respondents for increasing their knowledge and adoption of dry land technologies. administrations, researcher and extension workers may adopt suitable strategies for mitigating the constraints of farmers adopting dry land technologies as it is as beneficial and sustainable technology for farming.

Keywords: Impediments, Constraints, Farmers, Adoption, Dry land Technologies.

Introduction

Indian agriculture is predominantly a rainfed agriculture under which both dry farming and dry land agriculture are included. Out of the 143 million hectare of total cultivated area in the country, 101 million hectare (i.e. nearly 70 percent) areas are rainfed. In dry land areas, variation in amount and distribution of rainfall influence the crop production as well as socio-economic conditions of farmers. The dry land areas of the country contribute about 42 percent of the total food grain production. Most of the coarse grains like Sorghum, Pearl millet, Finger millet and other millets are grown in dry lands only. The attention has been paid in the country towards development of dry land farming.

Maharashtra state has highest proportion of rainfed areas among the states. About 85 per cent of net cultivated area is rainfed. Agriculture in Vidarbha region is also characterized by rainfed farming, the dry land agriculture. In dry lands the annual rainfall is about 750 mm to 1500 mm but its distribution throughout the year is not uniform. Particularly in Akola district, most of the area comes under dry land farming, farmers using latest dry land technologies by which yield potential per unit area is also increasing one but the profit is not found satisfactory as compare to its adoptions. This may due to lack of scientific knowledge and skill about use of different dry land technologies. Hence to ascertain, these facts the present study entitled 'Constraints faced by the farmer in adoption of dry land technologies' was.

Methodology

The study was carried out in the Akola and Akot tahsil of Akola district of Vidarbha region of Maharashtra state. The total ten villages were selected for the study from Akola and Akot tahsil. Further a list of the dry land farmers from the selected villages was prepared and sampling was done. The maximum area under dry land farming was considered for either selection on tahsil, village and farmers i.e. random sampling method was followed, from the selected village, 12 dry land farmers from each village were selected randomly. Thus in all 120 dry land farmers were selected for the present study. All these respondents were personally contacted and interviewed with the help of constructed and pre-tested interview schedule and the relevant data was collected.

Results and Discussions

The constraints faced in adoption of dry land technologies by the dry land farmers were ascertained in the study.

From the Table 1, it is seen that the uncertainty of weather 89.16 per cent, non availability of rain water at proper time 85.83 per cent, inadequacy of capital 84.16 per cent, non availability of labours 79.16 per cent, dry seeding in cotton is not possible due to uncertainty of rains and soil type (black cotton soil) 71.66 per cent, contour sowing or contour bunding operation not adopted due to difficulty in cultivation 69.16 per cent, non availability of vetiver grass for planting on contour 67.50 per cent, were the major constraints faced by the farmers in adoption of dry land technologies. It is also revealed that non availability of improved implements 63.33 per cent, lack of proper guidance 54.16 per cent, and inconvenience in intercropping in contour sowing 50.83 per cent were the important constraints faced by majority of the farmers in adoption of dry land technologies. Also it has been observed that lack of knowledge about the practice 45.83 per cent, non availability of quality seed 40.83 per cent, intercrop of tur does not perform well when intercropped with jawar 40.00 per cent, mung does not perform well in jawar 30.83 per cent, uneconomic land holding 20.00 per cent were the major constraints faced by the farmers in adoption of dry land technologies.

Table 1 : Constraints faced by respondents

Sr. No.	Constraints	Frequency	Percentage	Rank
1	Uncertainty of weather	107	89.16	I
2	Non availability of rain water at proper time	103	85.83	II
3	Inadequacy of capital	101	84.16	III
4	Non availability of labours	95	79.16	IV
5	Dry seeding in cotton is not possible due to uncertainty of rains and soil type (black cotton soil)	86	71.66	V
6	Contour sowing or contour bunding operation not adopted due to difficulty in cultivation	83	69.16	VI
7	Non availability of vetiver grass for planting on contour	81	67.50	VII
8	Non availability of improved implements	76	63.33	VIII
9	Lack of proper guidance	65	54.16	IX
10	Inconvenience in intercropping in contour sowing.	61	50.83	X
11	Lack of knowledge about the practice	55	45.83	XI
12	Non availability of quality seed	49	40.83	XII
13	Intercrop of tur does not perform well when intercropped with jawar.	48	40.00	XIII
14	Mung does not perform well in jawar	37	30.83	XIV
15	Uneconomic land holding	24	20.00	XV

These results are in closed conformity with the findings of Bhaskaran and Praveena (1982), Bhoite and Nimje (1983), Rao (2008) and Bhugul et. al. (2009).

Conclusions

It can be concluded that the majority of the dry land farmers faced the major constraints in adoption of dry land technologies and also obtaining benefit from dry land technologies such as Uncertainty of weather, Non availability of rain water at proper time, Inadequacy of capital, Non availability of labours, Dry seeding in cotton is not possible due to uncertainty of rains and soil type(black cotton soil) etc. For overcoming these constraints organizing exposure visits, demonstrations, trainings etc. were organized to the respondents for increasing their knowledge and adoption of dry land technologies. Administrations, researcher and extension workers may adopt suitable strategies for mitigating the constraints of farmers adopting dry land technologies as it is as beneficial and sustainable technology for farming.

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Effect of Precooling and Storage Conditions on Shelf Life of Aonla Fruits

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Abstract: Precooling is the process of rapid removal of field heat from freshly harvested fruits and vegetables prior to loading for transport to markets before storage which will inhibit growth of decay producing micro-organisms, restrict enzymatic and respiratory activities, inhibit water loss and reduces ethylene production in the product. Three types of precooling i.e. hydrocooling, forced air cooling and chilled water dipping at three different temperatures (4 °C, 6 °C and 8 °C) were conducted. The effect of pre-cooling methods on shelf life of aonla fruit was studied. The precooled samples air-dried for removal of surface moisture, samples were divided into three sub samples and then stored under ambient condition (30 ± 3 °C), transport condition (13.0 ± 0.2 °C & 85-90% RH), and cold storage (4.0 ± 0.2 °C). The physiological parameters like physiological loss in weight, percent spoilage and firmness in fruit and biochemical parameters like changes in total soluble solids, ascorbic acid content were observed at three days interval throughout the shelf life. The study concluded that that 8 °C chilled water dipping stored in cold storage as the best treatment for the precooling of aonla as it gave the shelf life advantage of 8 days without chemical treatment and 14 days with chemical treatment as well as it recorded lowest spoilage and physiological loss in weight compared to all other hydrocooling and forced air cooling treatments.

Keywords: Pre-cooling, storage, ascorbic acid content, shelf life, aonla.

Introduction

Aonla (*Emblica officinalis L.)* or Indian gooseberry is indigenous to Indian sub-continent. It is highly nutritive with a great medicinal value and is the richest source of vitamin C even greater than that present in guava, citrus and tomato fruits. The vitamin C content in pulp of fresh fruit is 200-900 mg/100 g (Goyal *et al.*, 2008). Its other constituents are phenols and tannins containing gallic acid, elegiac acid and glucose which prevent oxidation of vitamin C. It has been observed that ascorbic acid and other polyphenols present in natural extracts of Aonla show superior antioxidant activity and counteracting the toxic effects of metal salts in hepatic and renal toxins than equivalent amount of pure ascorbic acid (Nath, 1990). The total post harvest losses are estimated to be 20-30 % amounting nearly 8000 crore annually depending upon the post harvest handling systems and fruit varieties (Singh *et al.*,1993). One of the most important factor affecting the post-harvest life and quality of horticulture crop is temperature. Quality losses after harvest occur as a result of physiological and biological processes, the rate of which is influenced primarily by product temperature (Brosnan *et al.*, 2001). Low temperature handling and storage are the most important physical method of postharvest management.

Precooling is defined as a process in which the fruit must be cooled to required temperature which will inhibit growth of decay producing micro-organisms, restrict enzymatic and respiratory activities, inhibit water loss and reduces ethylene production in the product (Hardenburg *et al.*, 1990). It involves rapid removal of field heat from freshly harvested fruits and vegetables prior to loading for transport to markets before storage. Within precooling, numerous techniques exist for removal of field heat and increasing shelf life of fruits. Hydrocooling, forced air cooling, vacuum cooling, top icing, evaporative cooling and room cooling are the methods in commercial use at present (Joshi, 2004). Experiment was conducted to study the effects of various precooling methods on shelf-life of aonla fruits, evaluate the precooling characteristics of aonla fruits for different precooling methods, study the effects of various storage methods on shelf-life of precooled aonla fruits, and determine the physical and bio-chemical changes during storage of aonla fruits.

Materials and Methods

The aonla (Anand Aonla-II) fruits were harvested from the Experimental farm, Department of Horticulture, Anand Agricultural University, Anand and brought to the Post Harvest Engineering laboratory of the Post Graduate Institute of Food Processing Technology and Bio-Energy for further studies. The fruits were cleaned, graded for precooling treatment. The experiment was conducted in two phases. In the first phase three types of precooling i.e. hydrocooling, forced air cooling and chilled water dipping at three different temperatures (4 °C, 6 °C and 8 °C) were conducted. The samples were treated with various treatment combinations namely T_1- Hydro cooling at 4 °C, T_2- Hydro cooling at 6 °C, T_3- Hydro cooling at 8 °C, T_4- Forced air Cooling at 4 °C, T_5- Forced air Cooling at 6 °C, T_6- Forced air Cooling at 8 °C, T_7- Chilled water Dipping at 4 °C, T_8- Chilled water Dipping at 6 °C, T_9- Chilled water Dipping at 8 °C, T_{10}- control. Various observations like precooling time, temperature ratio; cooling coefficient, half cooling time and precooling temperature were made at the time of precooling. The precooled samples were stored in the three storage environments, i.e., room temperature, refrigerated transport condition and cold storage. During the storage period per cent spoilage, firmness was absorbed and the changes in total soluble solids (TSS) and ascorbic acid content were monitored. In the second phase, precooling experiment was conducted by selecting best precooling method and temperature from the first phase. The precooling experiments with chemical treatment and without chemical treatment were compared.

The precooled samples air-dried for removal of surface moisture, samples were divided into three sub samples for different storage conditions. The precooled sub samples were packed in corrugated fiber boxes with paper liner as cushioning material and then stored in ambient condition (30 ± 3 °C), transport condition (13.0 ± 0.2 °C & 85-90% RH), and cold storage (4.0 ± 0.2 °C). The stored samples were evaluated periodically for physiological loss in weight, firmness, spoilage, total soluble solids (TSS) and ascorbic acid.

Results and Discussion

Effect of precooling methods on cooling rate

Monitoring fruit temperature as a function of time during precooling in various methods revealed that the precooling system of fruit dipped in chilled water treatment was the fastest method to bring down desired precooling temperature (10 °C). Above method required only 4.5, 7.5 and 9 min to bring down fruit temperature from 25 °C to 10 °C precooling for the media temperature of 4 °C, 6 °C and 8 °C, respectively as shown in Fig 1 followed by hydro cooling 8, 21 and 30 min and forced air cooling 31.75, 44 and 63.75 min. The lesser time required for hydro cooling and dipping in chilled water compared to forced air cooling may be due to continuous and thorough contact of cold water with fruits and higher heat transfer coefficient of water as compared to air. The rate of cooling is directly related to the temperature difference between the product and cooling medium (Prange, 1994). Initially, when the product is warm, temperature drops quite rapidly; later, the rate slows as product temperature drops. Typical time- temperature curve follows the exponential form.

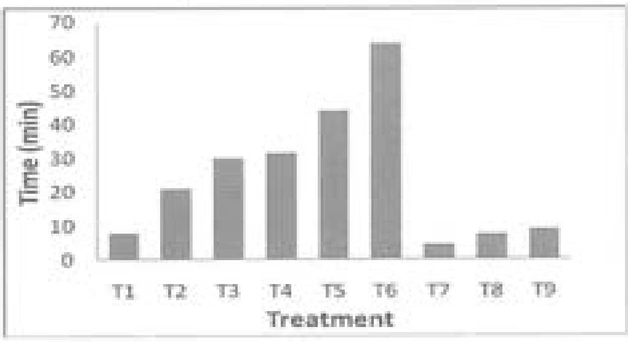

Fig. 1 Time required for different precooling methods

Table 1: Shelf life of aonla at different storage methods

Treatment	Shelf life (Days)		
	Ambient storage	Transport Condition	Cold Storage
T1	10 (1 day)	19 (4 days)	30 (3 days)
T2	10 (1 day)	19 (4 days)	30 (3 days)
T3	10 (1 day)	19 (4 days)	30 (3 days)
T4	10 (1 day)	20 (5 days)	31 (4 days)
T5	10 (1 day)	20 (5 days)	31 (4 days)
T6	11 (2 days)	21 (6 days)	32 (5 days)
T7	11 (2 days)	21 (6 days)	31 (4 days)
T8	11 (2 days)	21 (6 days)	31 (4 days)
T9	12 (3 days)	22 (7 days)	35 (8 days)
T10	9	15	27

* figures in parenthesis indicates advantage in days over control

From Table 1, the precooling method found to give maximum shelf life was (T_9) dipping in chilled water at 8 °C and storing it in cold storage over ambient storage and transport conditions. The second phase of experimentation consisted of precooling using treatment (T_9) with and without chemical treatments along with control; where, T_1- Best Precooling Method (with chemical treatment), T_2- Best Precooling Method (without chemical treatment), T_3- Control (with chemical treatment) and T_4- Control (without chemical treatment).

Effect of precooling treatment and storage method on Physiological loss in weight

From Table 2, it was observed that the Physiological Loss in Weight was maximum in room storage followed by cold storage and transport conditions. The maximum Physiological Loss in Weight was found in ambient storage (14.58 per cent), transport condition (8.86 per cent) and cold storage (10.88 per cent). The minimum Physiological Loss in Weight was found in chemical treated aonla of 8 °C chilled water dipping treatment under ambient storage (11.77 per cent), transport condition (7.91 per cent) and control in cold storage (8.28 per cent) at the end of the shelf life (Soni, 1998 and Uphadhyay, 1996).

Table 2 : Physiological loss in weight of aonla at the end of shelf life under different storage methods

Treatment	Physiological Loss in Weight						Mean
	Ambient condition		Transport Condition		Cold Storage		
	%	Days	%	Days	%	Days	
T1	11.77	12	7.91	24	9.28	41	9.65
T2	12.41	12	8.86	22	8.8	35	10.02
T3	12.62	10	8.1	18	10.88	31	10.53
T4	14.58	9	5.32	15	8.28	27	9.39
Mean	13.54	10.75	8.44	19.75	9.68	30.4	
S. Em	P = 0.42		T = 0.49		P X T = 0.85		
C.D. (P=0.05)	**P = 1.24**		**T = 1.43**		**P X T = NS**		
C.V. : 13.51%							

Effect of precooling treatment and storage method on firmness

It was observed from Table 3 that the firmness of the aonla in ambient storage conditions decreases (minimum 46.30 kg F) but the firmness increases slowly in the case of transport storage (maximum 73.81 kg F) and cold storage (maximum 77.44 kg F) as the storage period increases. There was no significant difference between the treatments (Soni, 1998 and Uphadhyay, 1996).

Table 3 : Firmness of aonla at the end of shelf life under different storage methods

Treatment	Firmness						Mean
	Ambient condition		Transport Condition		Cold Storage		
	Kg F	Days	Kg F	Days	Kg F	Days	
T1	47.94	12	78.36	24	79.56	41	68.62
T2	46.47	12	75.63	22	77.67	35	66.59
T3	42.39	10	72	18	77.43	31	63.94
T4	44.4	9	69.24	15	75.09	27	62.91
Mean	45.3	10.75	73.81	19.75	77.44	33.5	
S. Em	P = 0.85		T = 0.98		P X T = 1.70		
C.D. (P=0.05)	**P = 2.47**		**T = 2.86**		**P X T = NS**		
C.V. : 4.45 %							

Effect of precooling treatment and storage method on total soluble solids

Minimum Total Soluble Solids was observed under ambient storage (18.63 °Brix), transport condition (17.95 °Brix) and cold storage (18.43 °Brix) in control treatment. The maximum TSS was observed in control without chemical treatment in ambient storage (18.93 ° Brix), transport condition (18.13 °Brix) and cold storage (19.27 °Brix) in control with chemical treatment treatments at the end of the shelf life (Table 4) (Kumar *et al.*, 2005).

Table 4: Total soluble solids of aonla at the end of shelf life under different storage methods

Treatment	Total Soluble Solids						Mean
	Ambient condition		Transport Condition		Cold Storage		
	° Brix	Days	° Brix	Days	° Brix	Days	
T1	18.27	12	17.93	24	18.33	41	18.18
T2	18.73	12	18.00	22	17.60	35	18.11
T3	18.60	10	18.13	18	19.27	31	18.67
T4	18.93	9	17.73	15	18.53	27	18.40
Mean	18.63	10.75	17.95	19.75	18.43	33.5	
S. Em	P =0.08		T = 0.09		P X T = 0.16		
C.D. (P=0.05)	**P = 0.24**		**T = 0.27**		**P X T = 0.48**		
C.V. : 1.54 %							

Effect of precooling treatment and storage method on ascorbic acid content

The retention of ascorbic acid content of aonla under ambient, transport and cold storage condition by precooling and chemical treatment are shown in the Table 5. The maximum retention of ascorbic acid content in aonla fruit was found in ambient storage (455.21 mg/100g), transport condition (438.58 mg/100g) and cold storage (427.36 mg/100g) (Nath, 1990).

Table 5 : Ascorbic acid content of aonla at the end of shelf life under different storage methods

Treatment	Ascorbic acid content						Mean
	Ambient condition		Transport Condition		Cold Storage		
	mg/100 g	Days	mg/100 g	Days	mg/100 g	Days	
T1	454.60	12	450.18	24	410.65	41	438.48
T2	439.51	12	432.92	22	454.68	35	435.7
T3	466.07	10	436.30	18	454.57	31	445.65
T4	460.66	9	434.92	15	429.53	27	441.7
Mean	455.21	10.75	438.58	19.75	427.36	33.5	
S. Em	P =4.58		T =5.28		P X T =9.16		
C.D. (P=0.05)	**P = 13.37**		**T = NS**		**P X T = NS**		
C.V. : 3.60 %							

Effect of precooling treatment and storage method on spoilage

The values of spoilage of aonla under ambient, transport and cold storage condition by precooling and chemical treatment are shown in the Table 6. The maximum spoilage was observed under room temperature (42.72 per cent) followed by transport condition (32.02 per cent) and cold storage (12.10 per cent). The minimum spoilage was observed in the cold storage treatments among all three storage conditions. Compared to all treatments, 8 °C chilled water dipping with chemical treatment having less spoilage after storing at cold storage after 27 days Nath (1992).

Table 6: Spoilage of aonla at the end of shelf life in different storage methods

Treatment	Spoilage						Mean
	Ambient condition		Transport Condition		Cold Storage		
	%	Days	%	Days	%	Days	
T1	29.78	12	26.54	24	8.38	41	21.57
T2	33.82	12	29.24	22	7.95	35	23.67
T3	42.40	10	32.02	18	12.10	31	28.84
T4	42.72	9	30.03	15	11.86	27	28.2
Mean	37.18	10.75	29.46	19.75	10.07	33.5	
S. Em	P = 0.59		T =0.69		P X T = 1.19		
C.D. (P=0.05)	**P = 1.73**		**T = 2.00**		**P X T =3.47**		
C.V. : 8.04 %							

Effect of precooling and storage condition on shelf life of aonla

It was cleared from Table 7 that the maximum shelf life of 41 days was found in the 8 °C chilled water dipping with chemical treatment followed by 35 days in 8 °C chilled water dipping without chemical treatment and 31 days in chemically treated control in cold storage conditions. In transport condition, 8 °C chilled water dipping treatment gave maximum shelf life of 24 days followed by 22 days for 8 °C chilled water dipping treatment without chemical treatment. In ambient storage condition, 8 °C chilled water dipping treatment gave maximum shelf life of 12 days followed by 11 days in the 8 °C chilled water dipping treatment without chemical treatment.

In control treatments, the maximum shelf life was found with chemical treatment upto 31 days under cold storage compared with 18 days in transport condition and 10 days under ambient storage. The maximum shelf life of 27 days was found in control without chemical treatment in cold storage compared with 15 days in transport condition and 9 days under ambient storage.

It can be concluded that the precooling treatment 8 °C chilled water dipping with chemical treatment provides the maximum shelf life of 41 days under the cold storage condition (Tandon *et al.,* 2005).

Table 7: Shelf life of aonla at different storage methods

Treatment	Room Storage	Transport Condition	Cold Storage
T1	12 (2 days)	24 (6 days)	41 (10 days)
T2	12 (3 days)	22 (7 days)	35 (8 days)
T3	10	18	31
T4	9	15	27

*** figures in parenthesis indicates advantage in days over control**

Conclusion

From the experiments, it can be concluded that 8 °C chilled water dipping stored in cold storage as the best treatment for the precooling of aonla as it gave the shelf life advantage of 8 days without chemical treatment and 14 days with chemical treatment as well as it recorded lowest spoilage and Physiological Loss in Weight (PLW) compared to all other hydrocooling and forced air cooling treatments.

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Effect of Blanching Treatment and Tray Load on Drying Characteristics of Fenugreek (*Trigonella Foenum Graecum* L.) Leaves

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Abstract: Green leafy vegetables are highly perishable in nature but can be preserved by variousmethods including dehydration which is eco-friendly and easily adoptable. An investigationwas undertaken to study the effect of different blanching pre-treatments, tray load and drying temperature on drying characteristics of fenugreek (*Trigonella FoenumGraecum* L.) leaves. Three different pre-treatments (i) control (ii) dipping in 2% KMS for 2 minutes, at 50 ℃ temperature (iii) dipping for 15 seconds in warm water at 65 ℃ and cooling immediately in tap water were taken. Two methods of drying were used as sun drying and tray drying. Tray drying with three temperature level as 40 ℃, 45 ℃, 50℃ and material load in tray with two different level as 0.031 g/cm^{2}and 0.062 g/cm^2 per tray was taken. The drying characteristics of fenugreek leaves were recorded. In Sun drying, the treatment S_2takes minimum drying time 12 h whereas treatment S_3 takes maximum drying time 15 h.The treatment T_{14} and T_4 were taken minimum and maximum drying time respectively 7 h and 14 h in tray drying. The drying time decreases when drying temperature increases whereas the tray load of drying increases, the drying time also increases. Statistical analysis shows significant variation ($pp< 0.05$)were observed for drying rate and moisture content among all treatments.

Keywords: Fenugreek leaves, drying characteristics,blanching treatment, drying tray load, sun drying and tray drying.

Introduction

Fenugreek is a member of the Leguminosae family,perishable nature and can be preserved by proper processing. Its leaves contain 6% carbohydrate, 4% of protein and 1% fat (Gopalan *et al.*, 1971). The green leaves and seeds of fenugreek areutilized in food preparation as well as medicinal purpose. Dried leaves enhance flavour and color of food materials. Leafy vegetables have high moisture content ranges from 80-92% (w.b) and it is available for short time. Removing moisture from fenugreek leaves is mustrequire storing it for long time and full filling round the year utilization demand.However, leafy vegetables are highly perishable and heavy losses occur due to non-availability of sufficient storage, transport and proper processing facilities at the production points (Pande*et al.* 2000). Drying is the traditional method of preservation of highlyperishable agricultural produces. (Vega-Gálvez, Uribe, Lemus, & Miranda, 2007). Drying is the process of heat and mass transfer which reduces water activity in the product (Akpinar, 2006). Sun drying of fenugreek leaves is carried out but it is time consuming operation with contamination loss (Tuncer 1995; Oztekin *et al.* 1999). Drying in controlled atmospheric condition is best alternative to sun drying. It includes hot-air dryers and solar dryers. Drying process becomes more rapid with hygienic products in these dryers. Hot air dryer has more advantage of maintain uniformity in drying (Minguez-Mosquera et al. 1994; Tiris *et al.* 1994; Ayensu 1997). Pande *et al.*, (2000) had used forced circulation air dryer for drying of fenugreek and coriander leaves at different temperatures and dried samples were accepted by sensory panel. Jain *et al.*, (2003) had studied dehydration characteristics of spinach in air recirculatory tray dryer.

Several pre-treatments have been developed for fruits and vegetables for drying operation. It helps to inactivate enzymes and improve quality of final product. These pre-treatments involve heat treatment for a short time period, usually by either steam or hot water. Heat treatment for enzymes inactivation depends upon temperature and time (Adams 1978). Blanching with potassium metabisulphite (KMS) before drying improves the texture and colour of the dried material (Prajapati *et al.* 2009).Blanched paprika samples were dried with higher drying rate as compared to non-blanched samples during far-infrared (FIR) drying (Orikasa *et al.*, 2018). Drying of onion with pre-treatment with salt solution reducedthe drying time with good final product (Sahoo et al., 2015).Thus, the studieswere undertaken to study the effect of different blanching pre-treatments, tray load and drying temperature on drying characteristics of fenugreek (*Trigonella FoenumGraecum* L.) leaves.

Material And Methods

1. Procurement and preparation of material

Fresh Fenugreek leaves were procured from a local market of Dediapada.The leaves and soft stems were cleaned and sorted and then washed in tap water to remove the dirt and dust. Approximately 37 kg of leaves have been used for carrying out various experiments.

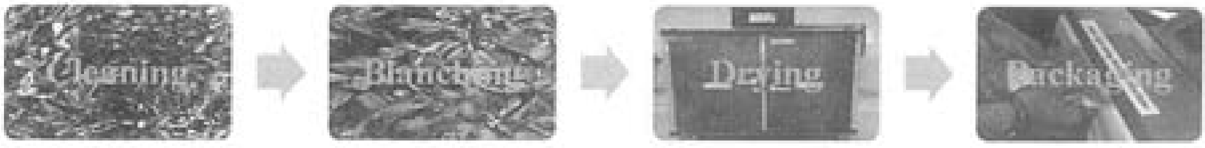

Table 1 : List of different pre-treatments

Treatment	Description
B_1	Control (without pre-treatment)
B_2	Dipping in 2% KMS for 2 minutes, at 50 ℃ temperature
B_3	Dipping for 15 seconds in warm water at 65 ℃ and cooling immediately in tap water

Table 2 : List of treatments for sun drying

Sr. no.	Load	Sample Code	Treatment
1.	L_1	$L_1 B_1$	S_1
2.		$L_1 B_3$	S_2
3.	L_2	$L_2 B_1$	S_3
4.		$L_2 B_3$	S_4

Table 3 : List of treatments for tray drying

Temp.	Load	Sample Code	Treatment
X_1	L_1	$X_1L_1 B_1$	T_1
		$X_1L_1 B_2$	T_2
		$X_1L_1 B_3$	T_3
	L_2	$X_1L_2 B_1$	T_4
		$X_1L_2 B_2$	T_5
		$X_1L_2 B_3$	T_6
X_2	L_1	$X_2L_1 B_1$	T_7
		$X_2L_1 B_2$	T_8
		$X_2L_1 B_3$	T_9
	L_2	$X_2L_2 B_1$	T_{10}
		$X_2L_2 B_2$	T_{11}
		$X_2L_2 B_3$	T_{12}
X_3	L_1	$X_3L_1 B_1$	T_{13}
		$X_3L_1 B_2$	T_{14}
		$X_3L_1 B_3$	T_{15}
	L_2	$X_3L_2 B_1$	T_{16}
		$X_3L_2 B_2$	T_{17}
		$X_3L_2 B_3$	T_{18}

Where, $X_1 = 40\ ^0C$ $L_1 = 0.031\ g/cm^2$

$X_2 = 45\ ^0C$ $L_2 = 0.062\ g/cm^2$

$X_3 = 50\ ^0C$

2. Selection of pre-treatments

The pre-treatments selected for the present study are given in Table 1.

3. Drying of control and pre-treated fenugreek

A sample were given the above pre-treatments and dried in open sun with loading density 0.031 g/cm^2 and 0.062 g/cm^2.

A sample were given the above pre-treatments was dried in an electric tray dryer with loading density 0.031 g/cm^2 and 0.062 g/cm^2 and different temperature as 40 ℃, 45 ℃ and 50 ℃.

Study of sun drying was carried out with four different treatments as given Table 2. study was done by spreading the weighted materials on black polyethylene sheet.

Study of tray drying was carried out with eighteen different treatments as given in Table 3. Inside the Tray dryer, 24 stainless steel trays could be placed one over the other with fixed clearance between each other. Two ventilation vents were provided on the side walls of the cabinet to partially exhaust the wet air out of the dryer. The temperature of the hot air was monitored with the help of as digital temperature controller provided at the top of the cabinet and the temperature could be maintained from ambient temperature up to 175±20 ^{0}C using a thermostat control. Drying was done in a non-perforated tray (80 cm x 40 cm x 3.5 cm). The material to be dried was spread in the trays.

Reading for Sun drying and Tray drying was taken at one-hour interval till constant moisture content arrived.

Moisture content

Moisture content of freshly harvested fenugreek leaves was measured just before the start of the experiment. Standard hot air oven method used for the leafy vegetables (AOAC, 1970 and ASAE Standard, 1991) was employed for moisture content determination of the fenugreek leaves. The percent moisture content was determined using flowing equations.

$$\text{Moisture content (wb)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where, W_1 and W_2 = Initial andfinal weight of samples g

Drying rate

Drying rate of dried fenugreek leaves was calculated using the following equation,

$$\text{Drying Rate (g w/ g dm-min)} = \frac{\text{Amount of moisture removed}}{\text{Time taken x (dry wt. of sample/100)}}$$

Statistical analysis

An ANOVA study was performed withFCRD (factorial completely randomized design)for determining the effect of pre-treatments, temperature and loading density on quality of the final product using significance level of 5%.

Results and Discussion

Drying characteristics of fenugreek leaves under open sun drying

The fresh fenugreek leaves were convectively dried in open sun and their drying behaviour were investigated.

Moisture Content *versus* drying timefor open sun drying

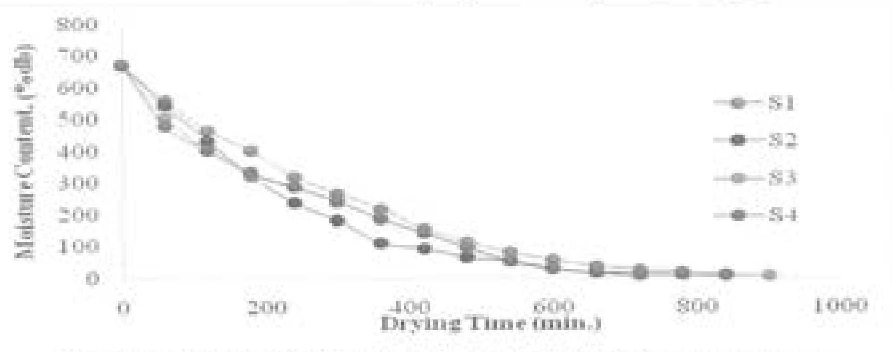

Figure 1: Drying behaviour of fenugreek leaves in open sun drying

From Figure 1, it can be observed that the moisture removal at the initial period of drying was higher in both treatments. there was not much variation in the drying behaviour of fenugreek leaves with and without pre-treatment. However, the final moisture content of the samples was differed slightly. The lesser time required of samples suggests comparatively faster removal of moisture.

Drying Rate *versus* moisture content for open sun drying

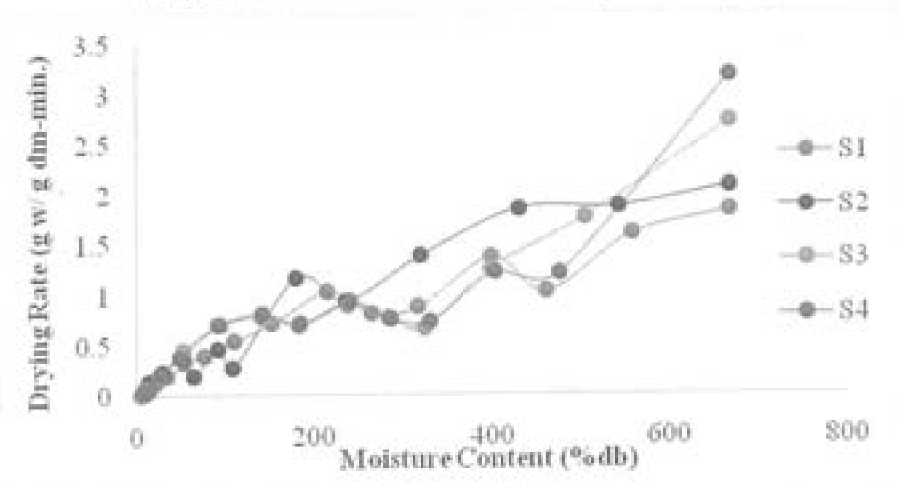

Figure 2 : Drying Rate of fenugreek leaves in Open Sun drying

From Figure 2, it can be observed that the rate of drying at the initial period of drying was higher in both treatments.Highest drying rate 3.191 g/min recorded for 200 g sample (load L_2) of hot water treatment. Lowest drying rate 1.83 g/min recorded for 100 g sample (load L_1) of without treatment.

Drying Rate *versus* drying time for open sun drying

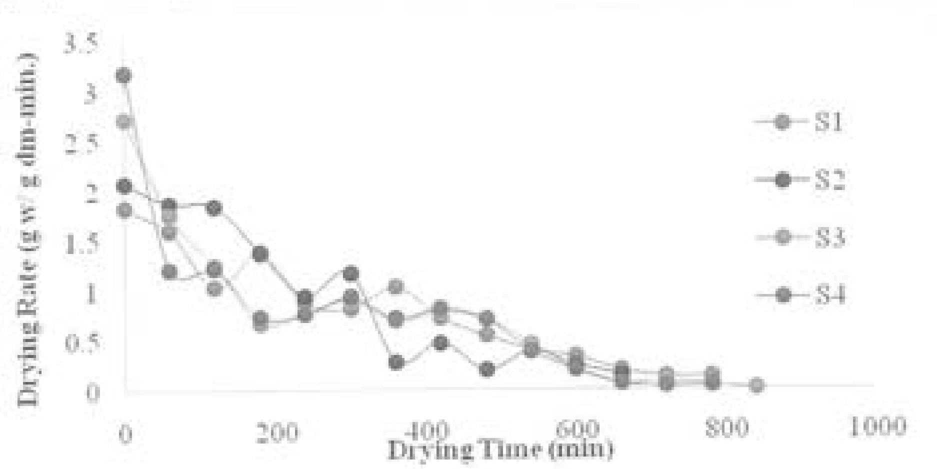

Figure 3 : Drying Rate of fenugreek leaves in Open Sun drying

It can be observed that at the initial stages of drying, the rate of drying was higher and at the final stages of drying the rate of drying was very much less as compared to initial stages. This was obvious, because at the onset of drying process the amount of moisture being high, higher moisture was available to evaporate per unit time. At later stages of drying, the diffusion of moisture from entire part of the leaves and to the surface was limited which eventually caused the reduction in drying time. Absence of constant rate period of drying suggests that there was no free water available on the surface of the leaves. The minimum drying time (12 h) was observed for S_2 treatment and maximum drying time (15 h) was observed for S_3 treatment.

Moisture Content for tray drying at different drying temperature and different tray loads

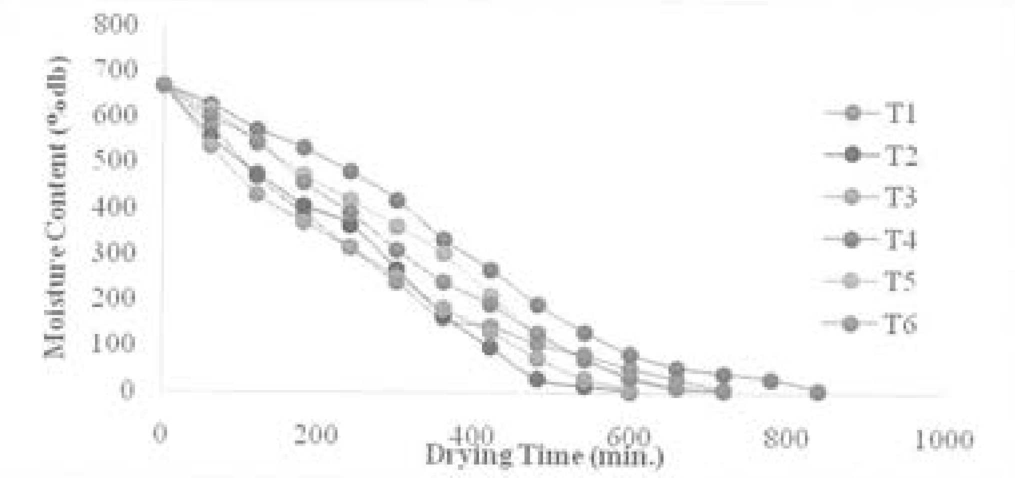

Figure 4 : Drying behaviour of fenugreek leaves in tray drying at 40 °C temperature

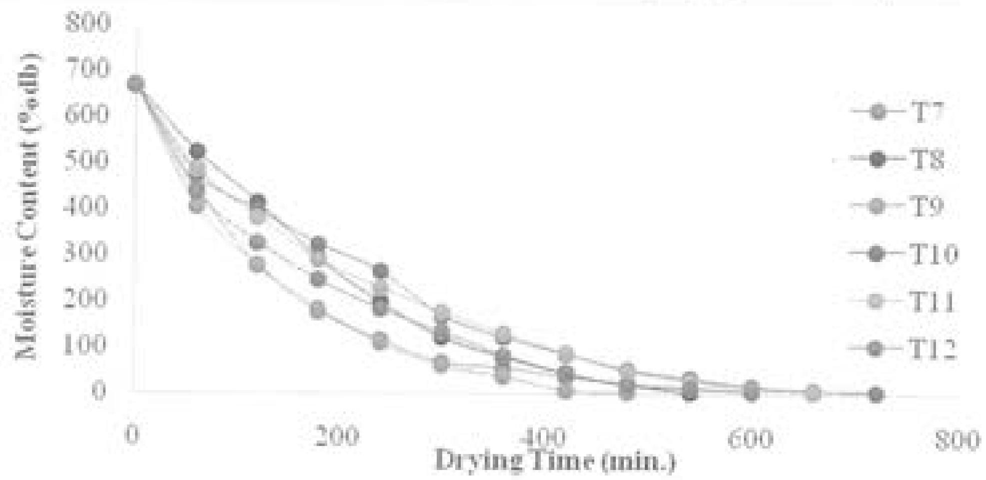

Figure 5: Drying behaviour of fenugreek leaves in tray drying at 45 °C temperature

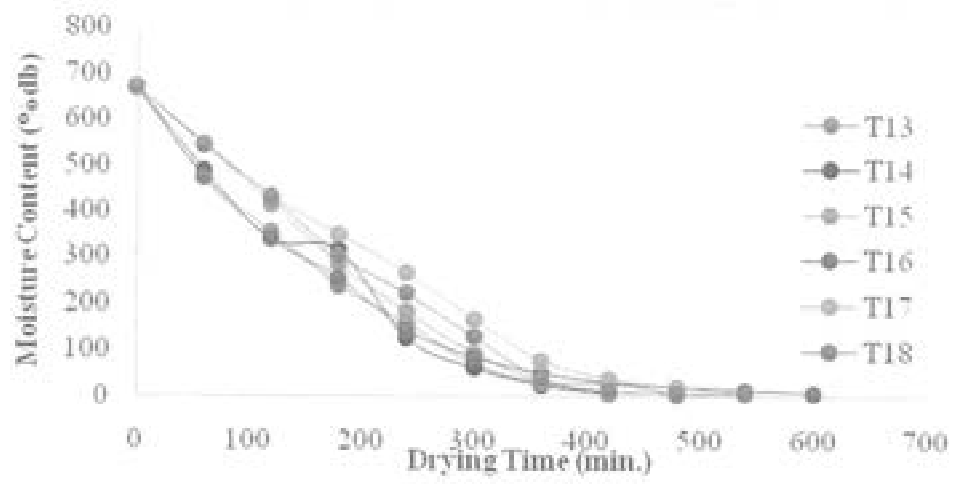

Figure 6: Drying behaviour of fenugreek leaves in tray drying at 50 °C temperature

From Figure 4, 5 and 6, it can be observed that the rate of moisture removal in 40 °C was slower as compare to other temperature and also among all three temperatures maximum rate of moisture removal observed in 50 °C. It was also observed that the rates of moisture removal were found higher in initial stages up to 5h and after that the rate of moisture removals were found lower for approximately all the treatments. It may be due to falling rate, critical point and constant rate drying of fenugreek leaves.

It was observed that there was variation in the drying behavior of fenugreek leaves with and without pre-treatment. However, the final moisture content of the all treatments was slightly differed.

Drying Rate *versus* Moisture Content for tray drying at different drying temperature and different tray loads

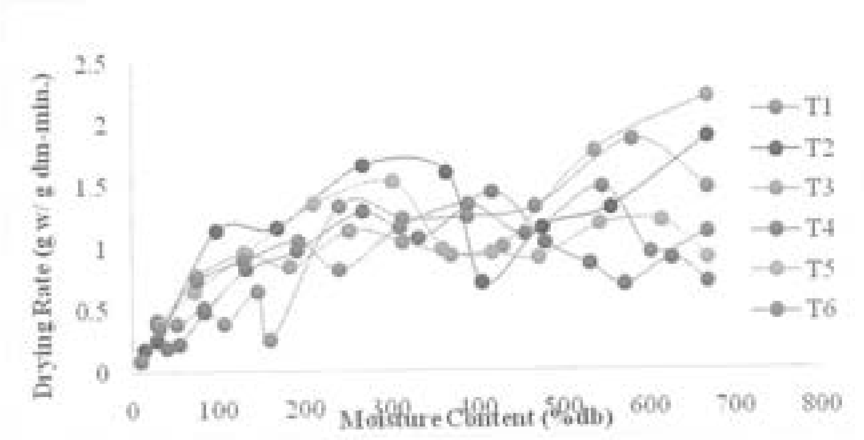

Figure 7 : Drying Rate of fenugreek leaves in tray drying at 40 °C temperature

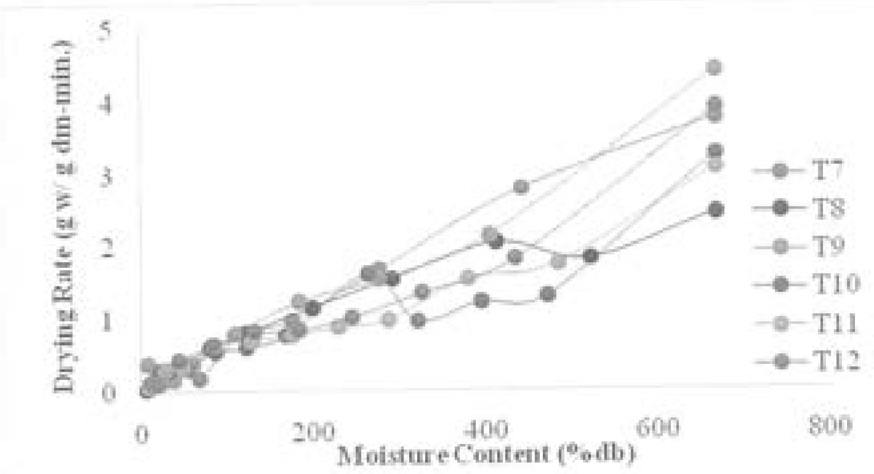

Figure 8 : Drying Rate of fenugreek leaves in tray drying at 45 °C temperature

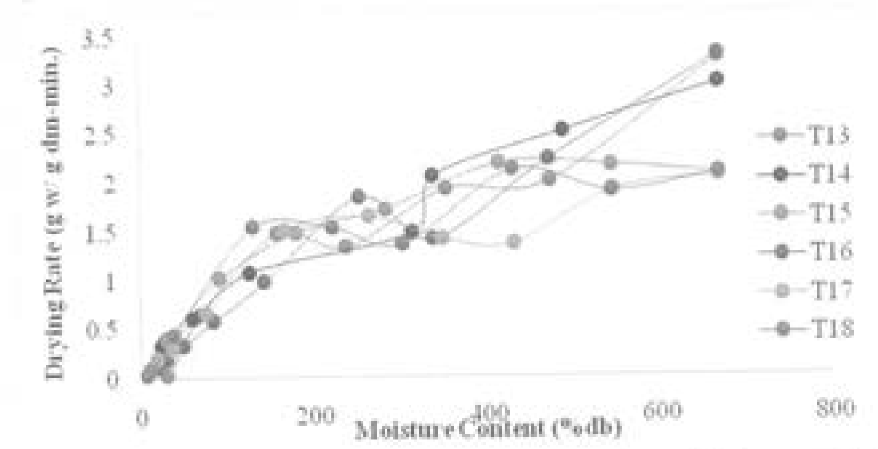

Figure 9 : Drying Rate of fenugreek leaves in tray drying at 50 °C temperature

From Figure 7, 8, and 9, it can be observed that apart from temperature 45 °C and 50 °C, there was much variation in drying rate for temperature 40 °C as shown in Figure 7. The rate of drying at the initial period of drying was higher in 45 °C and 50 °C compared to 40 °C.

Drying Rate *versus* drying time for tray drying at different drying temperature and different tray loads

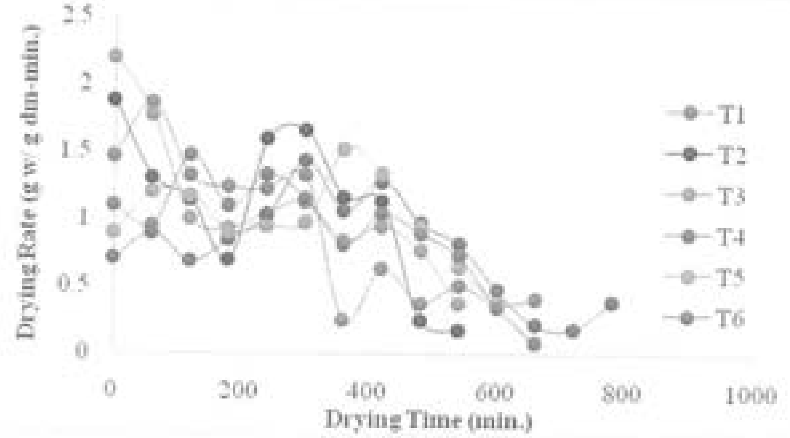

Figure 10 : Drying Rate of fenugreek leaves in tray drying at 40 °C temperature

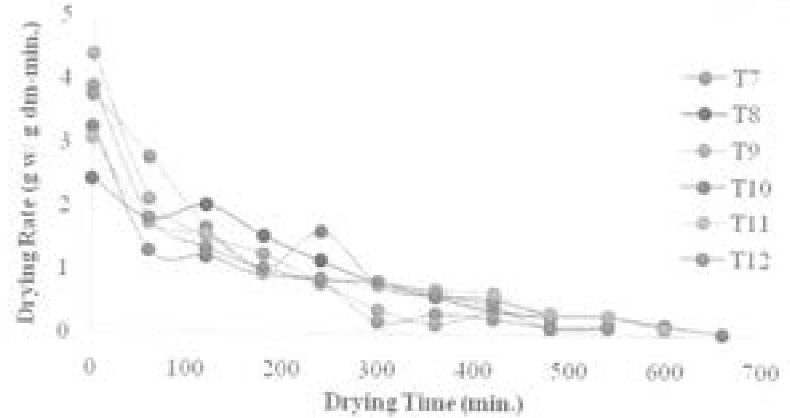

Figure 11 : Drying Rate of fenugreek leaves in tray drying at 45 °C temperature

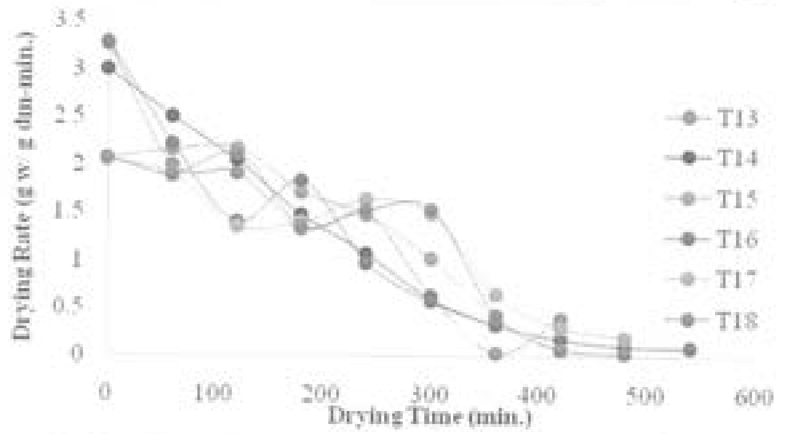

Figure 12: Drying Rate of fenugreek leaves in tray drying at 50 °C temperature

It can be observed that at the initial stages of drying, the rate of drying was higher which gradually reduced with the progress of drying time and at the final stages of drying the rate of drying was very much less compared to the initial stages. At later stages of drying, the diffusion of moisture from entire part of the leaves and to the surface was limited which eventually caused the reduction in drying time.The graph between drying rate and drying time for fenugreek leaves at 40 °C temperature was found uneven or zig-zag, it may be due to low drying temperature.

Total drying time for drying fenugreek leaves in sun drying and tray drying

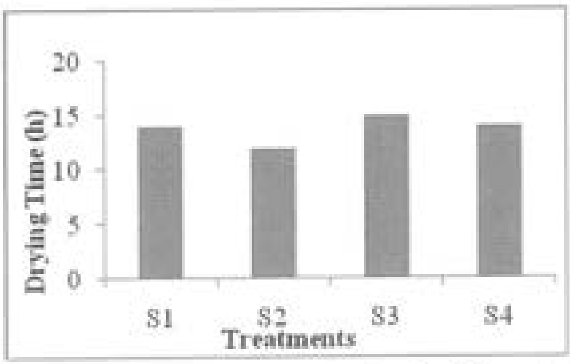

Figure 13 : Drying time for open sun drying for different treatments

Figure 13 shows, the maximum drying time 15 h was found for treatment S_3 and the minimum drying time was only 12 h for treatment S_2 to attain constant moisture content. Thus, it shows that pre-treatment samples gave lesser drying time as compared to without pre-treatment samples.

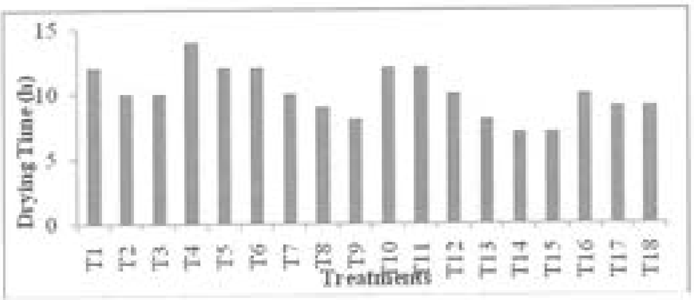

Figure 14 : Drying time for tray drying for different treatments

Figure 14 shows, the maximum drying time 14 h was found for treatment T_4 and the minimum drying time 7 h were for treatments T_{14} and T_{15} to attain constant moisture content. It was also found minimum drying time was observed for higher temperature 50 °C and pre-treatment with KMS and hot water. Thus, it shows that pre-treatment samples gave lesser drying time as compared to without pre-treatment samples.

Statistical Analysis

Table 4 : ANOVA of sun drying method

Treatment	Drying rate	Moisture content (%db)
S_1	0.79	224.61
S_2	0.79	185.80
S_3	0.92	211.99
S_4	0.79	197.02
MEAN	0.83	204.86
CV%	7.32	9.54
SEM	0.05	0.45
CD at 5%	0.14	1.32
TEST	Significant	Significant

Table 5 : ANOVA of tray drying method

Treatment	Drying rate	Moisture content (%db)
T_1	0.92	250.52
T_2	0.87	296.67
T_3	1.10	278.54
T_4	0.92	296.37
T_5	1.10	273.68
T_6	0.91	282.56
T_7	1.10	172.28
T_8	0.92	201.99
T_9	1.23	237.85
T_{10}	1.00	212.29
T_{11}	1.38	195.59
T_{12}	1.10	196.82
T_{13}	1.38	225.23
T_{14}	1.10	189.13
T_{15}	1.58	253.85
T_{16}	1.22	257.05
T_{17}	1.58	278.12
T_{18}	1.22	236.59
MEAN	1.12	240.84
CV%	6.10	8.61
SEM	0.03	0.32
CD at 5%	0.11	0.86
TEST	Significant	Significant

Table 4 and 5 shows that ANOVA for drying rate and moisture content proves statistically significant at significance level of 5%.

Conclusion

In sun drying, the minimum drying time (12 h) was observed for S_2 treatment and maximum drying time (15 h) was observed for S_3 treatment. In tray drying, the maximum drying time (14 h) was found for treatment T_4 and the minimum drying time (7 h) were for treatments T_{14} and T_{15} to attain constant moisture content. It was also found minimum drying time was observed for higher temperature (50 °C) and pre-treatment with KMS and hot water. Thus, it shows that pre-treatment samples gave lesser drying time as compared to without pre-treatment samples.

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load. Many times power requirement of load does not match with power output of the panel. In such situations there is a need of another unit in solar system that is **Electronic Controller** or it is also called **Power Conditioning Unit**. This unit is installed in between solar panel and load. Source of energy for a solar system is solar energy. The system will not work when there is no availability of the sun. So there is a need of mechanism which could store the electrical energy produced in day time to be used when there is no sun. **Battery** can be used to store such type of electrical energy. Produced electrical energy can also be stored in **Electrical grid**. Hence one more component, **storage medium** is added to the solar system which may be either battery or electrical grid. Such a solar system is shown in Fig. 1.

If the storage medium is electricity grid, the solar system is called **Grid-connected solar system**. In case solar system not interacted with the grid and whole system (includes battery as storage) is in the house, such type solar systems are called **Off-grid solar system**. Sometimes a hybrid solar system is also possible in which energy is stored in both grid and battery. This type solar system is called **Hybrid solar system**.

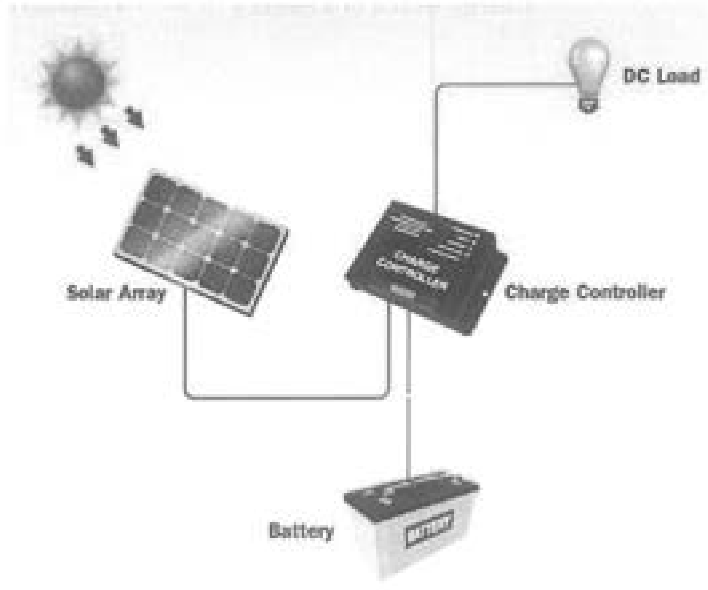

Fig. 1: DC based solar system

Solar Panels

Solar panel is a small power plant. Coal and hydro power plants require various arrangements to work, while solar panel generates electricity in a simple way [4]. Electricity from solar panel can be generated locally and it is a smart and environment friendly technology. So it makes sense to use solar electricity.

Technical specifications of a solar panel

A solar panel is specified in terms of its power rating. Unit of power is 'watt' hence solar panels are rated in watts. In market solar panels are available in different power ratings like 1 W, 5 W, 10 W, 50 W, 100 W, 250 W and 300 W. Peak or Maximum Power (W_p or W_{max} or P_{max}) of a solar panel is defined as:

$$P_{max} = V_{mp} X I_{mp}$$

Where, V_{mp} = Voltage at maximum power point

I_{mp} = Current at maximum power point

Area requirement of solar panel

A thumbrule to determine the area required for solar panel is that if the efficiency of solar panel is 15 %, the panel will produce 150 W/m^2 (15 X 10 =150) and if the efficiency is 18 %, it will produce 180 W/m^2 (18 X 10 = 180). We can say that power produce is 10 times more the efficiency of solar panel. Area required for small family size electricity requirements, is not much. House rooftop is quite sufficient for such req uirements.

Basics of Batteries

Batteries are delicate part of solar system. Batteries are not required for grid connected solar system. To make an independent solar system batteries are must. Such solar systems are referred to as standalone solar systems [5].

Charge capacity of a battery

Battery is a tank of charge. Unit of battery charge measurement is **Ampere-hour (Ah).**

Batteries in the market are available with charge capacities of 2 Ah, 10 Ah, 20 Ah, 50 Ah, 100 Ah and 200 Ah etc.

Energy stored in a battery

In earlier sections we learnt the electrical energy used by appliances at home and energy produced by a solar panel in a day. Similarly energy stored in a battery can be computed by:

Energy stored in a battery = **Terminal voltage (V) X Charge capacity (Ah)**
= V X Ah
= (V X A) X h
= Power X hour
= Watt X h = Wh *OR* WHr
= **Unit of Energy**

Energy extractable from a battery

All the energy stored in a battery cannot be utilized. The percentage of energy that can be taken out of a battery is termed as **Depth of Discharge (DoD)**. That means DoD of batteries is not 100 %. In case of Lead-acid batteries DoD is 50 % and that for Lithium-ion batteries is 80-90 %.

Electronic management of solar systems

Electronic management is similar to work of heart in our body. Just like heart in human body supplies blood to every part of the body, Electronic Management manages power in every component of the solar system. Since electronic management manages power in all the components (Solar panel, load and battery) of the solar system, all the components are connected to the electronic management as shown in Fig. 2.

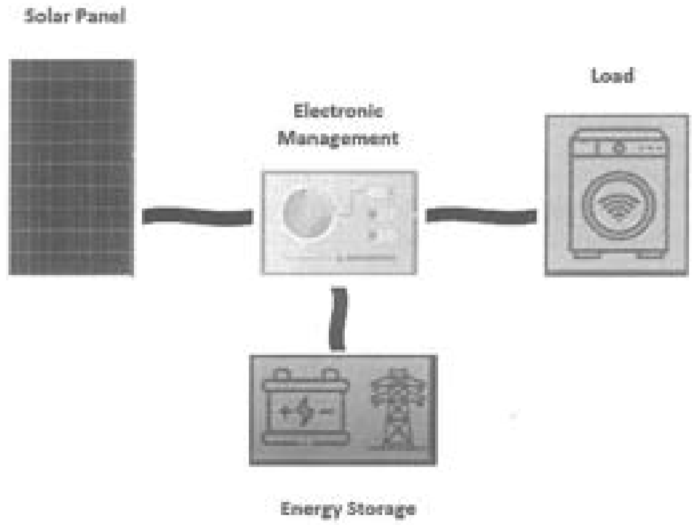

Fig. 2: Electronic Management in Solar System

Roles of electronic management system

Electronic management system has following roles in solar system

1. It helps to extract maximum power from connected solar panel.
2. It helps to protect connected battery from over-charge and over-discharge.
3. It helps to supply right voltage and current to connected appliances (load).

There are two types of solar based electronic management system:

1. Gives Alternating Current (AC) power output (Inverter) [6]
2. Gives Direct Current (DC) power output (charge controller) [7]

1. AC based electronic management system

Solar panel produces direct current (DC). Energy stored in the battery is also in the form of DC. In the case if home appliances work on alternating current (AC), the electronic management system has to convert DC to AC before supplying to the appliances. In this case the electronic management system is **Inverter**. Inverter inverts DC into AC. The inverter also performs other roles of electronic management system. In India output of inverter is fixed as 230 V, 50 Hz. AC.

Power rating of inverter to be used with solar system should be sum of power of all the appliances used. Power rating of inverter is measured in W or kW or VA or kVA.

2. DC Based electronic management system:

The appliances which work on DC based supply, need DC based electronic management system. This system is called **Charge Controller**. Charge controller receives DC supply as input and it supplies DC as output. The charge controller also performs other roles of electronic management system.

Power rating of charge controller to be used with solar system should be sum of power of all the DC appliances used at home.

Design of a Solar System

Before learning the design of solar system we should know the law of energy conservation:

"Energy can neither be created nor it can be destroyed. It can be converted from one form to another form". This law can be explained by the Fig. 3:

Law of energy conservation is applied in solar system also. Every device in the system uses energy to perform any operation. For example inverter in a solar system converts DC into AC, while supplying battery power to the load. In this process of conversion some amount of energy is lost. So the sum of energy output from the inverter to the load and energy lost by the inverter, should be equal to the energy supplied to the inverter.

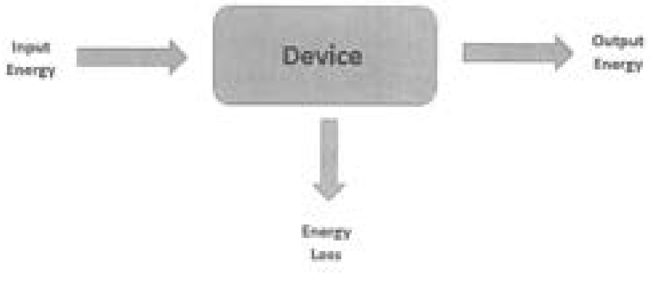

Fig. 3: Law of energy conservation

In order to design a solar system we need to do following things [8]:

i) Find the size of the components of solar system (Panel, battery, inverter etc.)

ii) Match the power and energy requirements of the appliances

Let us take an example of load of a home with following appliances as shown in Table 1 and calculate the total power end energy consumption.

Table 1: Load of a home for which solar system is to be designed

S. No.	Appliance	Power rating (W) (a)	No of appliances (b)	Usage per day (h) (c)	Total Power (W) d = a x b	Total Energy consumed (Wh) e = a x b xc
1	Light	20	4	6	80	480
2	Fan	15	3	8	45	360
3	Television	50	1	3	50	150
4	Washing Machine	200	1	1	200	200
5	Refrigerator	100	1	24	100	2400
6	AC, 1.5 Ton	1400	1	4	1400	5600
				Total	Total Power = 1875 W	Energy = 9190 Wh = 9.19 kWh

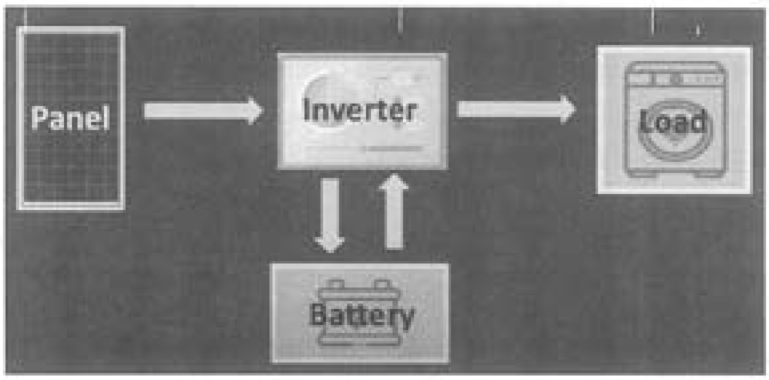

Fig. 4 : Sequence flow of energy in a solar system

Components of a solar system are Solar panel, inverter, battery and load. We need to find the size of these components. Flow of energy in a solar system occurs in a sequence from solar panel to inverter to battery and then to load as shown in Fig. 4. But design of solar system follows reverse path. That means first we find our load, then inverter, then battery and at last sizing of solar panel.

Inverter sizing

Inverter sizing is done based on the total power rating of the home. As observed from Table 1, column d, total power rating of the home is 1875 W. Inverter should be sized little higher than the total power of all appliances of the home. So an inverter of 2 kW or **2 kVA** would perform well with size of load.

From the example values of Table 1, column 'e', total energy consumed by all the loads is 9.19 kWh per day. That means this much energy is to be supplied by the inverter. Inverter itself has some internal losses. Assuming internal losses to be 20 % the input energy to the inverter should be:

The energy lost inside inverter for DC to AC conversion = 9.19 X 0.20 = 1.84 kWh per day

Total energy supplied to the inverter = Energy output by inverter + Energy loss inside inverter

= 9.19 + 1.84 = 11.03 kWh per day

Battery sizing

A battery does not discharge to its full capacity. Level of discharge is decided by Depth of Discharge of the battery. In case of Lead-acid battery DoD is approx. 50 % and that in case of Li-ion battery is approx. 90 %.

$$\text{Required battery capacity} = \frac{\text{Energy input to the inverter}}{\text{DoD}}$$

Hence assuming Lead-acid battery,

$$\text{Required battery capacity} = \frac{11.03}{0.50} = 22.06 \text{ kWh per day}$$

Batteries in the market are available in Voltage (V) and Ampere hour (Ah) rating.

Let us choose a battery of **12 V and 200 Ah** (2400 VAh = 2400 Wh = 2.4 kWh)

Now we need to find the number of batteries of 2.4 kWh Lead acid type to make total battery capacity of 22.06 kWh.

$$\text{Number of batteries required} = \frac{\text{Battery capactiy}}{\text{Capacity of one battery}}$$

Hence in our case;

$$\text{Number of batteries required} = \frac{22.06}{2.4} = 9.19$$

This figure can be rounded off to **10 Numbers of batteries (12 V, 200 Ah each)** for the ease making equal sets of combination with each other being in even number.

In case a user wants storage for more than one day the number of batteries with increase multiplying by number of days.

There is also some loss of energy inside the battery. Assuming a loss of 15 % inside battery:

The energy lost in the battery = 11.03 X 0.15 = 1.65 kWh/day

Total energy input to the battery = Energy output by battery + Energy loss in the battery

= 11.03 + 1.65 = 12.68 kWh per day

Solar Panel Sizing

Input energy to the battery is coming through inverter. Inver has certain electronics that takes care of charging and discharging of the battery and maximum power extraction from the solar panel. But this part of the inverter is very efficient and assuming 4% of loss through this part of inverter:

Energy lost in inverter = 12.68 X 0.04 = 0.51 kWh/day

Hence,

Energy input to the inverter from solar panel = Energy input to the battery + Energy lost in inverter

$$= 12.68 + 0.51 = 13.19 \text{ kWh/ day}$$

Like other components Solar panel too has losses. Typically the losses in the panel are higherdue to temperature, mismatch and dust deposition on the panel etc. Considering a loss of 25 % would be good.

Losses form solar panel = 13.19 X 0.25 = 3.30 kWh/day

Total energy solar panel must generate = Energy input to the inverter from solar panel + Energy lost from solar panel

$$= 13.19 + 3.30 = 16.49 \text{ kWh/day}$$

Now in order to find out the required power rating of solar panel we need to know the duration of availability of solar radiation per day, assuming 1000 W/m^2 (standard test condition) solar radiation.

Let us assume available solar radiation at given location is 5.5 kWh/m^2 per day

i.e. hours of solar radiation is 5.5 h/day [(5.5 X 1000 Wh/m^2/day) / (1000 W/m^2)]

$$\text{Power of solar panel required} = \frac{\text{Total energy solar panel must generate}}{\text{hours of solar radiation}}$$

$$\text{Power of solar panel required} = \frac{16.49}{5.5} = 3 \text{ kW} = 3000 \text{ W}$$

Suppose we take 300 W panels from the market;

$$\text{Number of solar panel required} = \frac{\text{Number of solar panel required}}{\text{Power of a single solar panel}}$$

$$\text{Number of solar panel required} = \frac{3000 \text{ W}}{300} = 10$$

Summary of Solar System Design

1. Load energy required = 9.19 kWh
2. Inverter power rating = 2 kVA
3. Battery storage (1 day) = 22.06 kWh per day, 10 batteries, 12 V, 200 Ah
4. Solar panel = 3 kW, 10 panels, 300 W

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Engineering Properties of Wood Apple (*Limonia acidissima L.*)

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Abstract: Wood apple (*Limoniaacidissima L.*) belongs to the family Rutacae and it is commonly found in dry plains of southern Maharashtra, West Bengal, Uttar Pradesh, Chhattisgarh, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala and certain regions of Western Himalayas. The wood apple is also known by different vernacular names such as kavatha, kaith, kathbael, elephant apple, monkey fruit, curd apple, golden apple, stone apple, etc. The indigenous fruit, wood apple has a high number of phytochemicals, vitamins, and amino acids. Besides, this fruit is one of the natural source of antioxidant, antidiabetic, antitumor, and antimicrobial activity. Wood apple is one of the underutilized medicinal fruit because of lack of mechanical technologies for post-harvest processing of fruit. The physical and mechanical properties of wood apple have very important role in developing new technologies for post-harvest processing of wood apple. The average moisture content of wood apple shell and pulp was found as 52.63 % and 76.12 %, (w.b.) respectively. The average length, breadth and thickness were 70±8.33, 70.70±9.13 and 69.20±8.87mm respectively whereas the average sphericity and weight found as 0.96 and 222.9 g respectively. The average bulk density, true density and porosity, angle of repose and coefficient of friction were 0.6744 g/cc, 1.0017 g/cc and 0.3268, 5.33 degree, 0.09329 respectively. The correlation between the fruit weight and other physical parameters of wood apple shows best fit of data. The mechanical properties viz. compressive stress and shear stress were found as 1421.46 N and 1291.76 N respectively.

Keywords: Wood apple, physical properties, mechanical properties.

Introduction

Wood apple (*Limonia acidissima L.*) is one of the important, underutilized and indigenous fruit plant. Wood apple has great demand as a medicinal fruit. Though it is useful, is underutilized because of its hard shell. The wood apple is also known by different vernacular names such as kavatha, kaith, kath bael, elephant apple, monkey fruit, curd apple, golden apple, stone apple, etc. Wood apple is native to India and common in dry plains of India, Pakistan and Sri Lanka (Khan *et.al*, 2019). It is found all over the plains of India, southern Maharashtra, West Bengal, Uttar Pradesh, Chhattisgarh, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala and certain regions of Western Himalayas. The wood apple is not under regular orcharding, however, along the border of fields, roads, railway lines and banks of the river, etc. are the common places where the plants are found as stray plant. Wood apple is a small to moderate size, deciduous, glabrous tree with thorny branches reaching to a height up to 10 metres with 0.6 metres to 1.6 meters girth (Kumar and Deen, 2017). A mature tree bears 200-250 fruits/tree (Amin *et.al*, 2017). The brown pulp of wood apple has a slightly sour taste on its ripe. The colour at the ripen stage becomes dark brown. Wood apple is rich in acid, minerals and pectin. Wood apple pulp contains about 74 % of moisture and 7.4 % of carbohydrates. As a medicinal plant, most of the studies on wood apple are based on leaves, bark and roots (Khan *et. al*, 2019). A feasible technology for post-harvest processing of wood apple is need of the hour.

Material and Methods

Materials

Matured wood apples of variety CH- 19 (elora) were taken from Department of Horticulture Dr. PDKV Akola. Damaged, under matured and over matured wood apple were discarded and the remaining healthy (Half ripe) wood apples were taken for the experiments.The materials used for the experiment were hot air oven, weighing balance, vernier caliper, measuring cylinder, frictional apparatus, universal testing machine, etc.

Methods

Moisture content (M.C.)

The moisture content of wood apples was determined by using gravimetric air oven. The wood apple was exposed to a temperature of 180°C which was set in the oven. The first step while measuring moisture content was that the weight of empty box (W_1). Then the weight of sample box with wood apple were measured (W_2). Once the desired temperature of 180°C reached, the sample along with box kept into the oven. After 6 h the box taken out from the oven and put into the desiccators for 30 min

(Yerima *et al.*, 2018). The sample box with sample was taken out from the desiccators and its weight taken as (W_3). The moisture content of the sample determined by using the following formula (Sahay and Singh, 1994).

$$\text{Moisture content, \% (wb)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100 \qquad \ldots(1)$$

Where, W_1 = Weight of sample box, g

W_2 = Weight of sample box with wood apple, g

W_3 = Weight of sample box and wood apple after heating in the oven, g.

Size and Shape

The size of the product was measured so that the design of cleaners, graders, winnowers, etc. can be possible. In the present experiment, size of the wood apple used to design the feeder and cutting mechanism of the machine. The total 30 numbers of wood apples were taken for the experiment. The spatial dimensions of the wood apple were measured by using Vernier Calliper (Mohsenin,1980).

Geometric mean diameter

The size of the wood apple determined with the help of geometric mean of the three dimensions, i.e. length, breadth and thickness. To determine the geometric mean diameter of the wood apple, spatial dimensions like length (L), breadth (B) and thickness (T) measure with the help of Vernier Calliper. The geometric mean diameter (D_g) of samples determined by using the following formula (Mohsenin,1980).

$$D_g = (L \times B \times T)^{\frac{1}{3}} \qquad \ldots(2)$$

Where, L = Length, mm; B = Breadth, mm' T = Thickness, mm

Sphericity

Sphericity is the ratio of diameter of sphere having same volume as that of the wood apple. The total 30 numbers of wood apple were taken for the experiment. The Sphericity (Sp) of wood apple was determined by using following formula (Mohsenin,1980).

$$Sp = \frac{(l \times b \times t)^{\frac{1}{3}}}{t} \qquad \ldots(3)$$

Where, l = length, mm; b = breadth, mm; t = thickness, mm

Surface Area

The total surface area over the periphery of wood apple, calculated using equation given as below (McCabe *et al.*,1986).

$$S = \pi (D_g)^2 \qquad \ldots(4)$$

Where, D_g is geometric mean diameter, mm

Volume and Specific Gravity

Volume of each wood apple fruit measured using water displacement method based on the Archimedes principle. Each wood apple fruit submerged in water filled in 500 cm^3 eureka container and the volume of displaced water was measured using graduated cylinder. After measuring the volume, the specific gravity of each fruit computed using the equation as below (Mohsenin,1980).

$$S_g = \frac{\text{Mass of air}}{\text{Volume of water}} \qquad \ldots(5)$$

Roundness

It is a measure of the sharpness of the corners of the sample. Total 30 number of wood apple were taken for the experiment. The following formula was used to determine the Roundness of wood apple (Mohsenin,1980).

$$\text{Roundness} = \frac{A_p}{A_c} \qquad ...(6)$$

Where, A_P = Largest projected area of object in natural rest position, mm^2

A_C = Area of smallest circumscribing circle, mm^2

True density

The true density determined by using the liquid displacement method. Total 30 number of wood apple were taken for the experiment. True density of the wood apple determined by using following formula (Kachru *et al.*,1994).

$$\text{Truedensity} = \frac{\text{Wight of wood appe (Wd)}}{\text{Displaced volume of the water (Vw)}} \qquad ...(7)$$

Bulk Density

It is the ratio of mass to the unit volume of the sample. Bulk density is important parameter in designing of different processing machineries like separators, handling equipments, dryers, storage and transportation machineries and systems. The bulk density of wood apple was used to determine capacity of drum and collection unit of the hopper. The bulk density determined with the help of Hectoliter apparatus. A cylindrical container of known volume (1000 ml) was used. It was filled with wood apple. After that the weight of the wood apple was measured using an electronic weighing balance of an accuracy of 0.001 g. The bulk density (ρ_b) calculated as the ratio of the weight of the wood apple to its volume (Chaudhari, 2013).

$$\text{Bulk Density} = \frac{\text{Weight of the sample \& the container}}{\text{Volume of the container}} \qquad ...(8)$$

Porosity

The percent void of an unconsolidated mass of the materials in terms of volume is called as porosity. The porosity of wood apple determined from the values of bulk density and true density by using the following relationship (Sahay and Singh, 1994).

$$\text{Porosity} = \frac{\text{True density} - \text{Bulk density}}{\text{Truedensity}} \times 100 \qquad ...(9)$$

Coefficient of friction

The coefficient of friction is an important property which helps to estimate the lateral pressure in storage silos, design the storage bins and hopper for the gravity discharge. These properties help to know flow ability of the sample in a machine. Total 30 number of wood apple were taken for the experiment (Sunmonu, 2015).

$$\mu = \tan\theta \qquad ...(9)$$

Where, μ = Coefficient of friction.

θ = Angle of tilt in degrees.

Mechanical Properties

The mechanical properties are used to determine the compressive strength, impact force, shear resistance etc. of the sample. The mechanical properties are important while designing the milling, cutting, handling, storage, transportation and food processing equipment (Sahay and Singh, 1994). Total 30 numbers of wood apples were taken for the experiment.

Stress

Stress is force acting per unit area which is perpendicular to the direction of force. The Universal Testing Machine (UTM) used to measure the stresses developed in the wood apple.

Stresses used to determine the rupture point of the wood apple with the help of Universal Testing Machine. The Universal Testing Machine has load cell, one moving platform, PC card Monitor, a driving unit and a data acquisition system. The procedure was used for testing of sample was as follows. Initially calibration of the UTM machine was done. The sample placed on the platform underneath load cell having probe attached. Due care taken so that the sample remain firm at its position during experimentation. Then the pre-programmed UTM machine allowed to move down the load cell with probe against the sample.

The observations were recorded in the software viz. the force required to initiate breaking and peak force required during breaking (Divekar and Rane, 2015).

Results and Discussion

Fruit Dimensions

The dimensions of wood apple fruit were taken along three axis viz. major, minor and perpendicular axis of wood apple and measured using vernier calliper. The maximum, minimum and average length of wood apple fruit was found as 90.91, 59.75 and 70.50±8.33 mm whereas the maximum, minimum and average fruit's breadth was obtained as 89.46 51.8 and 70.70±9.13 mm, respectively. The maximum, minimum and average value of the thickness of wood apple fruit was 89.37, 51.62 and 69.20±8.87 mm, respectively. Wood apple dimensions such as length, breadth and thickness were correlated with the weight of the fruit and it was found from fig. 1(a), (b), (c) that the correlation between dimension and fruit weight is satisfactory. The values of coefficient of determination (R^2) found as 0.814, 0.813 and 0.829 for length (a), breadth (b) and thickness (c), respectively.

Arithmetic Mean Diameter and Geometric Mean Diameter

From Table 1, it was observed that the value of maximum, minimum and average arithmetic mean diameter of wood apple fruit was found to be 89.91, 54.39 and 71.47±8.62 mm whereas the maximum, minimum and average geometric mean diameter was 89.91, 54.26 and 71.41±8.63 mm respectively. The arithmetic mean diameter and geometric mean diameter values were correlated with the fruits weight and the coefficient of determination of both (arithmetic mean diameter and geometric mean diameter) was found as 0.848. The comparison between arithmetic mean diameter and geometric mean diameter was evaluated using regression model. The result obtained the best fit of data with coefficient of determination 0.9912 (Figure 1g).

Sphericity

The sphericity was found in the range of 0.89 to 0.99 and the average value calculated as 0.95±15.55 as shown in Table 1. The sphericity is near to one indicates that the fruit is oval to round in shape and can easily roll or slide on flat smooth surface.

Weight and Volume

From Table 1, the average values of weight and volume were found as 222.99±74.32 g and 206.66±79.18 cm^3, respectively. Maximum weight of the wood apple was recorded as 411 g having volume of 415 cm^3. The weight and volume values are recorded at average moisture content of wood apple fruit as 75.13 %. The coefficient of variation for weight and volume estimated as 33.32 % and 38.31 %, respectively. Fig. 1(d) shows the correlation between weight and volume indicating the best fit of data. The maximum, minimum and average specific gravity of wood apple was found as 1.34, 0.820 and 1.10±0.10, respectively.

Moisture Content

The moisture content of wood apple measured using hot air oven. The samples were in the oven kept at 180°C for 6 h. The measurements were replicated thrice. From Table 1 the average moisture content of wood apple shell as 52.63±1.65 % (w.b) and it can be concluded that wood apple shell also contain minimum 50 % of moisture in maturity stage. Wood apple pulp moisture was determined as 75.13±0.18 % on (w.b), respectively. The moisture content is directly related to fruit weight. The moisture content helps in predicting fruit maturity; the immature fruit has more weight and greenish in colour compared to mature fruit which is relatively low in weight and brownish in colour.

Bulk Density and True Density

Bulk density and true density of wood apple were determined. The process was replicated thrice and the average true density and bulk density was calculated as 1.0017 and 0.6744 g/cc respectively, shown in table 3. The average porosity of wood apple determined as 32.67 %.

Angle of repose

The angle of repose of the wood apple was measured using the friction apparatus. As the wood apple is oval to round in shape, it can easily roll on plane surface. The average value for angle of repose of wood apple was found to 5.33 degree and the coefficient of friction 0.093 shown in table 3.

Mechanical properties of wood apple

The mechanical properties includes compressive and shear stress. The results of compressive stress and shear stress are discussed as follows.

Compressive Stress and shear Stress

The compressive stress of matured wood apple was measured using an Universal Testing Machine. From the Table 2, it is evident that compressive stress obtained in the range of 213.67 N to 2600.86 N. The average compressive stress of matured wood apple fruit obtained as 1421.72±710.58 N. The shear stress of matured wood apple fruit was in the range of 764.601 N to 1733.83 N whereas the average shear stress of matured wood apple fruit obtained as 1296.84±295.67 N. The obtained value of shear stress was lower compared to the value of compressive stress which concluded that wood apple fruit can be cut easily using shear force.

Table 1 : Physical properties of wood apple

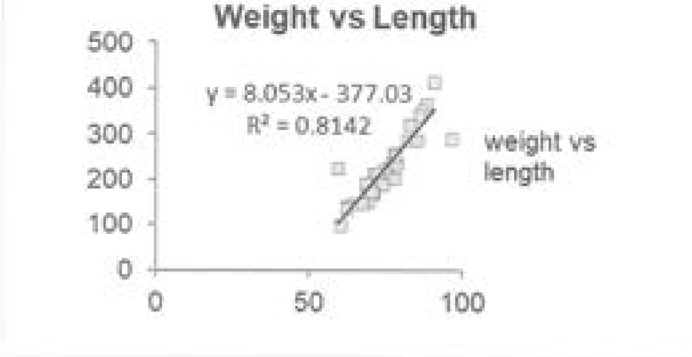
Particular	Sample size	Minimum	Maximum	Average	STD (±)	CV
Length (mm)	30	59.75	90.91	70.50	8.33	11.17
Breadth (mm)	30	51.8	89.46	70.70	9.13	12.90
Thickness (mm)	30	51.62	89.37	69.20	8.87	12.83
GMD (mm)	30	54.26	89.91	71.41	8.63	12.09
AMD (mm)	30	54.39	89.91	71.47	8.62	12.06
Sphericity (%)	30	0.893	0.995	0.957	15.55	18.68
Weight (g)	30	97.3	411	222.99	74.32	33.32
Volume (cm^3)	30	77	415	206.66	79.18	38.31
Sp. Gravity (g/mm^3)	30	0.820	1.34	1.100	0.10	9.21
Moisture content of shell, % (w. b.)	3	50.12	54.11	52.63	1.65	3.15
Moisture content of pulp, % (w. b.)	3	74.89	75.31	75.13	0.18	0.023

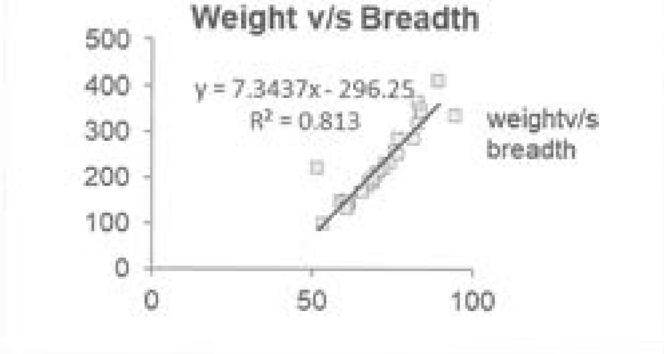
Table 2 : Mechanical properties of wood apple.

Sr. No.	Property	Average	STD(±)	CV
1	Compressive stress (N)	1421.46	710.58	49.98
2	Shear stress (N)	1291.76	295.67	22.88

Table 3 : Gravimetric and Frictional Properties

Sr. No.	Property	Value
1.	Bulk density (g/cc)	0.6744
2.	True density (g/cc)	1.0017
3.	Porosity (%)	0.3267
4.	Angle of repose, degree	5.33
5.	Coefficient of friction	0.093





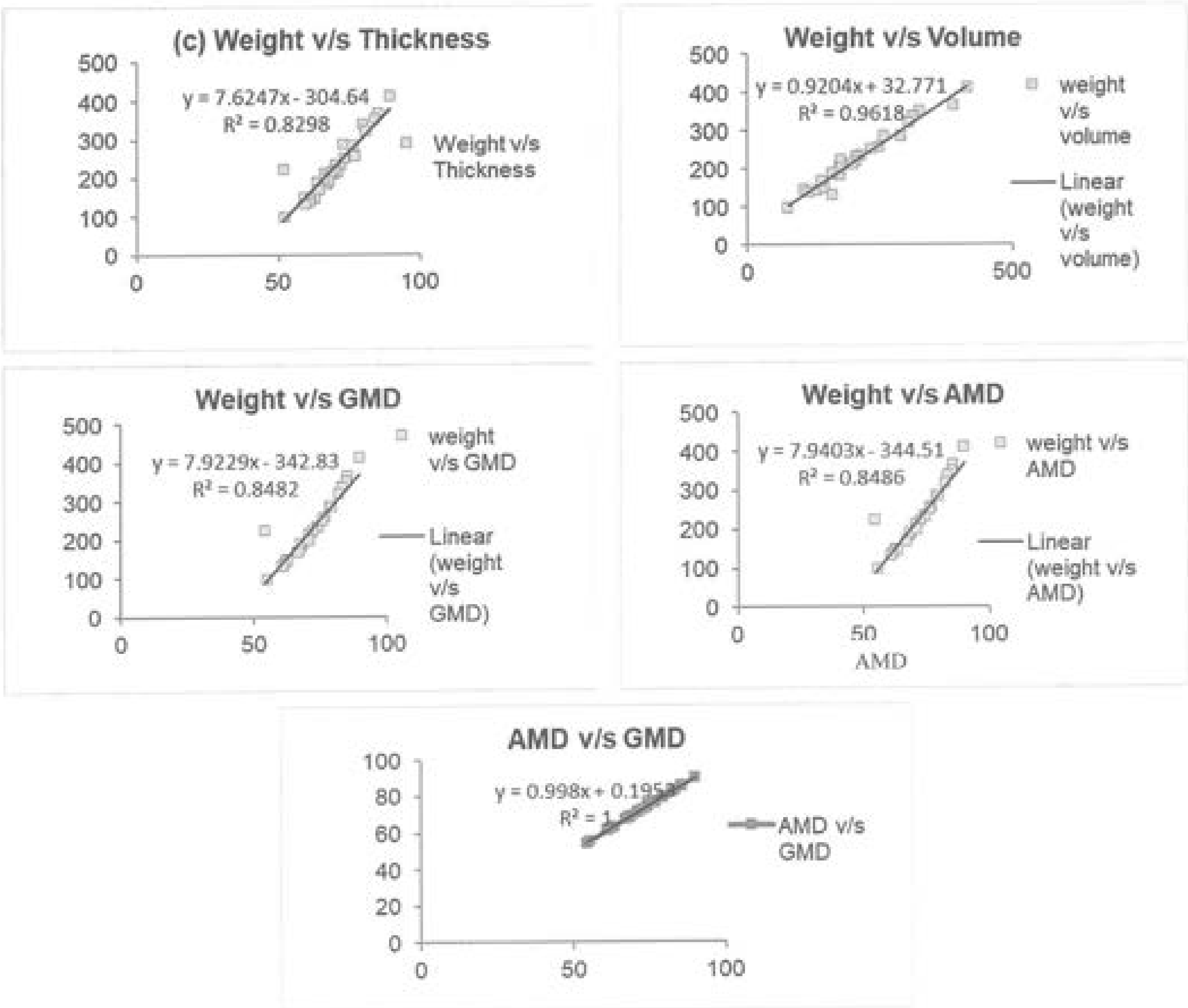


Fig. 1 Correlation between length (a), breadth (b), thickness (c), volume (d), AMD (e) and GMD (f) of fruit with the weight of the wood apple (g) Correlation between AMD and GMD

Conclusion

The average length, breadth and thickness were 70±8.33, 70.70±9.13 and 69.20±8.87 mm respectively. The average sphericity and weight found as 0.9578 and 222.9 g, respectively. The value of sphericity showed that the wood apple is round to oval in shape and can slide easily on flat surface. The average bulk density, true density and porosity, angle of repose and coefficient of friction were 0.6744 g/cc, 1.0017 g/cc and 0.3268, 5.33 degree, 0.09329, respectively. The mechanical properties viz. compressive stress and shear stress were measured as 1421.46 N and 1291.76 N, respectively.

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Advances in Pyrolysis Technology for Agricultural Applications: A Review

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Abstract: The actual role of bio-energy will depend on its competitiveness with fossil fuels and on agricultural policies worldwide, it seems realistic to expect that the current contribution of bio-energy of 40-55 EJ per year will increase considerably. A range from 200 to 300 EJ may be observed looking well into this century, making biomass a more important energy supply option than mineral oil today,While the intention of slow pyrolysis is to produce mainly charcoal, fast pyrolysis is meant to convert biomass to a maximum quantity of liquids (bio-oil). Both processes have in common that the biomass feedstock is densified to reduce storage space and transport costs. A comfortable, more stable and cleaner intermediate energy carrier is obtained, which is much more uniform and well defined. In this review, the principles of fast and slow pyrolysis are discussed.

Keywords: Pyrolysis, Technology, Review, Bio-oil, Biomass, Bio-energy

1. Introduction

Biomass resources are relatively uniformly available in India compared to other renewable sources and it is renewable source of energy. Biomass is generated from chemical storage of solar energy using the photosynthesis reaction. Biomass is used to generate energy is only form of renewable energy that can be used to decrease the effect of energy production and utilize on the global environment. In the developing countries, Biomass, such as surplus agricultural crop residues, agro waste, and forest waste are considered as a one of the best sources of energy which is renewable in nature, which ultimately help us to meet the heat and power energy demand. The consumption of the energy demand will gradually increase due to high population growth and economic development. Fossil fuels are non-renewable energy sources so which creates a harmful effect on environment such as emission of toxic gases into environment, increasing greenhouse gas emission etc. Owing to this problem in search of feasible renewable energy sources, energy production from biomass is considered as a best option (Chew and Doshi, 2011). In addition, biomass is the only renewable raw material or feedstock that can be converted into a variety of energy rich products such as liquid, solid, and gaseous fuels through different conversion routes.

In this review paper, an attempt has been made to discuss the potential of biomass in India, different biomass conversion technology, properties of bio-oil and its application etc.

1.1 Potential of Biomass in India

In India, the annual production of crop residues from agricultural land is more than 500 million tons (Mt) among these residues surplus crop residue indicates in the range of 84-141 Mt/yr. So, farmers in India are burning these surplus crop residues in open field which creates a hazy and smoky environment. The common biomass feedstock's available in India includes sugarcanebagasse,ricehusk,straw, cottonstalk,coconutshells,soyahusk,coffeewaste,jutewastes, groundnutshells,sawdust etc (Hilloidhari *et al.*,2014). Therefore, there is need to optimize a biomass conversion technologies for the production of value added energy rich products.A total 288 power generation using biomass and co-generation projects approximately 266 MW capacity has been installed in India for supplying power to the grid.

How to progress the living standards of the most agriculture based population in the world is one of the major problems faced all over the country (Chen *et al.* 2012). In 2031-2032, capacity of power generation may be increase near about 800 GW as compared to current capacity 183GW including daily need of energy (MNRE 2011). Kumar and Jain concluded that during the session of 1970-1971 to 2006-2007 In India coal consumption has increased up to 71.2 MT to 462.7 MT, crude petroleum consumption increases up to 18.4MT to 146.5MT and natural gas consumption up to 0.64 Giga cubic meters(GCM) to 31.36 (GCM).During the same time interval, the electric consumption also increases up to 43.3 TWh to 443.1 TWh.

1.2 Biomass Conversion Technology

Biomass can be converted into useful forms of energy using a number of different processes as shown in Fig1. The biomass can be converted into three main categories such aspower/heat generation and transportation fuels and another one is chemical feedstock. There are basically two biomass conversion routes first one is thermo-chemical and another one is biochemical.Mechanical extraction (with etherification) is the third technology for producing energy from biomass,e.g. rapeseed methyl ester (RME) bio-diesel. Currently the cost of bio-diesel compared with fossil fuel makes the technology more expensive but increasing environmental crises to improve air quality, especially in cities,may change this situation in the near future.In case of thermo chemical conversion of a biomass, there are four process of conversion are available such ascombustion, pyrolysis, gasification and liquefaction. On the other hand, in case of bio-chemical conversion process, one is anaerobic digestion and another one is fermentation are used all over.

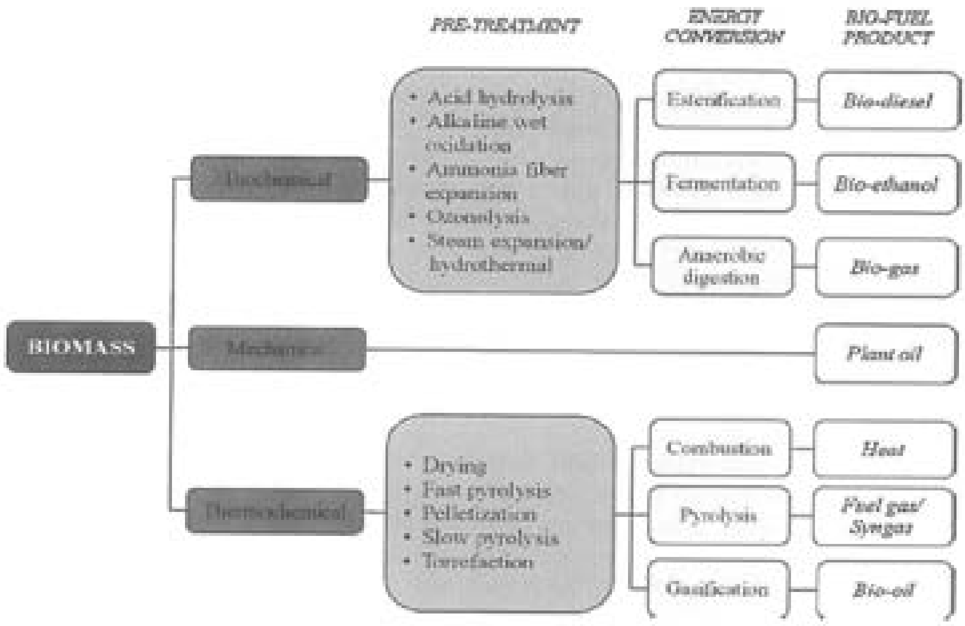

Fig. 1 : Modified summary of bio-fuel conversion routes(Chew and Doshi, 2011).

2. Pyrolysis

Pyrolysis is one of the most promising technologies of biomassutilization, which converts biomass resources to solid char, liquidoil, and biogas. In case of pyrolysis process heating of biomass takes place in absence of air, sometimes it is also known as destructive distillation of woody biomass. The heating rate and temperature are the mostcritical parameters in controlling the performance of biomasspyrolysis, particularly with reference to the yield distribution ofsolid, liquid, and gaseous products (Laird *et al.*, 2009).A flash heatingrate and temperatures of 400-600°C have been shown toprovide a high yield of liquid oil (Venderbosch and Prins, 2010).Pyrolysis of woody waste to produces bio-char, bio-oil like products as shown in Fig.2, has been suggested to ignore harmful impacts of direct burning (Chen *et al.*, 2012). The end products of pyrolysis process are char and predominantly bio-oil if fast or flash pyrolysis is used. The bio-char is preserved in the terrestrial system for longer duration than the plant residues or compost. The bio-oil can be used in engines and turbines and it could be used as a feedstock for refineries, as reported in old literatures. Problems with the conversion process and subsequent use of the oil,such as its poor thermal stability and its corrosivity,still need to be overcome.

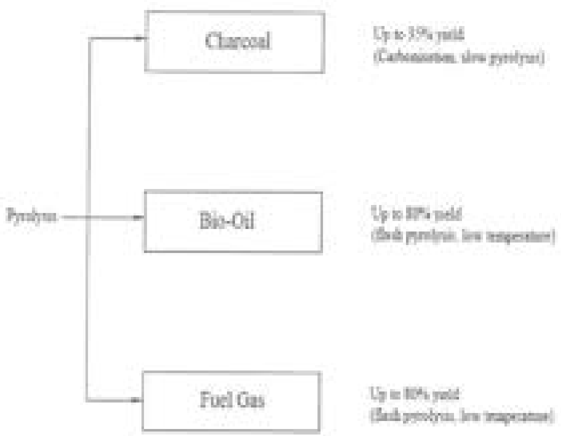

Fig. 2 Energy products from pyrolysis (Peter Mckendry, 2002)

2.1 Classification of Pyrolysis Process

Pyrolysis may be broadly divided into slow and fast process based onheating rate. Slow pyrolysis is known as a conventional process; require a very low heating rate. However, in case of fast pyrolysis process needs more time as compared to slow pyrolysis.

- Slow pyrolysis: $t_{heating} >> t_r$
- Fast pyrolysis: $t_{heating} << t_r$

Generally, pyrolysis process based ontwo type'sfirst one is on the basis of heating rate while another one is based on the environment in which pyrolysis is carried out:

1. Slow pyrolysis
2. Fast pyrolysis
3. Flash pyrolysis

Slow and fast pyrolysis process does not necessary a medium but another two types required a specific medium (1) Hydrous pyrolysis (H_2O) and (2) Hydro pyrolysis (H_2) this used only for chemical production.

In slow pyrolysis process, reaction time is varies from minutes or it may take longer duration for the production of char and owing to this it broadly classified as 1) Carbonization process 2) Conventional process. On the other hand, In case of fast pyrolysis process, reaction time is ranges from second to milli-seconds it is optimized during the production of liquid or gases by adopting mainly two types 1) Flash and 2) Ultra-rapid flash pyrolysis(Basu p. 72)

Table 1 indicates the comparative characteristics of different pyrolysis processes, and shows carbonization requires very low heating rate and more residence time. In addition, in case of ultra-rapid pyrolysis process requires very high heating rate and least of residence time. The main end products of carbonization process are charcoal and gases

Table 1 : Characteristics of some pyrolysis process (Basu p. 72)

Pyrolysis Process	Residence time	Heating rate	Final Temperature °C	Products
Carbonization	Days	Very low	400	Charcoal
Conventional	5-30 min	Low	600	Char, bio-oil, gas
Fast	<2 s	Very high	appro. 500	Bio-oil
Flash	<1 s	High	<650	Bio-oil, chemicals, gas
Ultra-rapid	< 0.5	Very high	appro. 1000	Chemicals, gas
Vacuum	2-30 s	Medium	400	Bio-oil
Hydro pyrolysis	< 10 s	High	< 500	Bio-oil
Methano-pyrolysis	< 10 s	High	< 700	Chemicals

2.1.1 Slow Pyrolysis Process

Slow pyrolysis process is thousand year old process and significantly used to enhance the heating value of feedstock by producing charcoal or bio-char. Carbonization is the slow pyrolysis process; the primary end product is obtained during the process is charcoal.The biomass is heated in the absence of air to a low temperature approximately 400°C. The yields of bio-char and bio-oil vary according to type of feedstock, its properties, processingtemperature, heating rate and the pyrolysis environment. For example, herbaceous biomass contains moreminerals than woody biomass, and thus gives minimum end products (Patwardhan *et al.* 2010). Yield of bio-char decreases with increasing pyrolysis temperature as shown in Fig. 3 because as pyrolysis temperature was raised there is possibility of burning of organic material in the biomass such as cellulose and hemi-cellulose at higher temperature. In slowpyrolysis, bio-char and bio-oil yields are dependent on the feedstock properties and operating temperatures, but there is no clear trend onthe effect of heating rate on yields as shown in Fig. 4 (Roy and Dias, 2017).

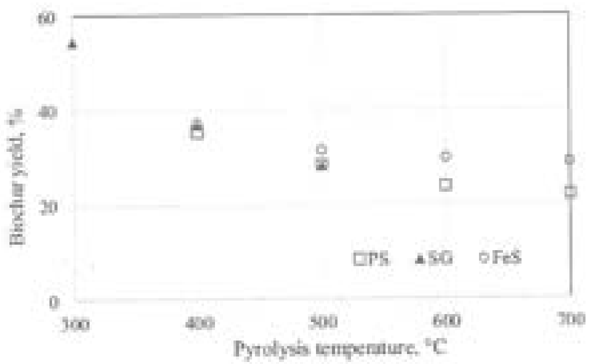

Fig. 3 Effect of pyrolysis temperature on Bio-char yield (PS: Pine shavings; SG: Switchgrass; FeS: Fescue straw). (Roy and Dias, 2017)

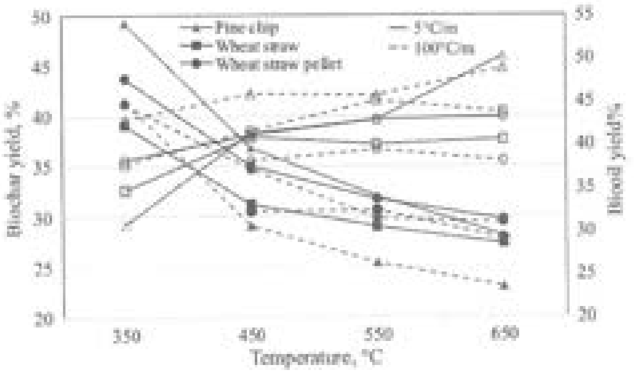

Fig. 4 Effect of pyrolysis temperature and heating rate on bio-char and bio-oil yield (bio-char: solid symbols; bio-oil: open symbols) (Crombie K, and Masek, 2014)

2.1.2 Fast Pyrolysis

The primary goal of fast pyrolysis process is to increases the production of liquid and bio-oil. The biomass is heated more rapidly it reaches the peak temperature before the material decomposes. Rate of heating the product might be high nearly about 1000 to 10,000°C/s but the peak temperature obtained near about 650°C if the bio-oil is end product (Basu, p.73). Several literatures also show that fast pyrolysis produces the maximum amount of bio-oil (75%) at around 500 °C(Roy and Dias, 2017).The production of bio-char and syngas using fast pyrolysis process are possible but as the syngas yield increases, the yield of bio-char and bio-oil automatically decreases.(Li. S. Xu*et al.*, 2004)

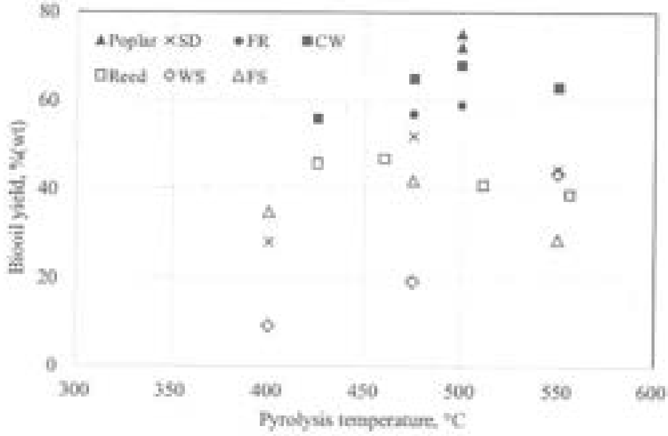

Fig 5 : Effect of pyrolysis temperature on bio-oil yield. (SD: sawdust; FR: Forest residues;CW: Clean wood; SG: Switchgrass; WS: wheat straw; FS: Flax straw) (Roy and Dias, 2017).

Yield of bio-oil is subsequently depending upon type of feedstock, its properties and pyrolysis parameters as shown in Fig. 5. Woody biomass shows maximum yield of bio-oil in case of fast pyrolysis process. Some researchers concluded the reason for t the highest bio-oil yield using a woody biomass in fast pyrolysis process thatiswoodybiomasscomprises of higher amount of cellulose and hemi-cellulose compared with another crops and agro-residues. Specifically, Azargohar *et al.*, found that for wheat straw, bio-oil yield increased continuously with increasing pyrolysis temperature(400-550 °C), but for flax straw and sawdust, yield decreased beyond500 °C.

During the fast pyrolysis process, feedstock particle size also affected on yields of bio-oil, bio-char and syngas.As particle size increases, the heattransfer rate decreases, and results in increasing bio-char yield and decreasing bio-oiland syngas yield. In smaller particle size, the heat transfer rates are limited and which increases the yield of bio-oil (Sharma *et al.*, 2015). Roy and Dias suggested that bio-oil yields for various feedstocks can be increased by optimizing bothconditions like pyrolysis temperature and feedstock particle size.

2.1.3 Flash pyrolysis

This is a special case of carbonization where the material is heated at a very rapid heating rate relatively more temperature range of 450 to 500°C. The product may be condensable and non-condensable gas, leave the paralyser within a short residence time of 30 to 1500 ms (Basu P. 73). Fig. 6 shows that the product yields during the temperature at 400, 500, 550, 600 and 700 °C for particle size range of +0.6-1.25mm under gas velocity of 100 cm^3/min. The temperature of pyrolysis was increased from 400 to 700°C the yield of product also increases up to 69 to 86%. It may conclude that the volatiles and decomposition of char particle preceded with increases the temperature of pyrolysis (Onay and Kockar 2003).

The pyrolysis temperature at 400°C production of char decreased from 31 to 14% and the oil was 58%. As the temperature increased from 400 to 550°C the liquid product increased from 58 to 72%.Then, increasing the final pyrolysis temperature to 700°C, the oil yield goes down to 68% (Fig. 6). It can be easily seen that the temperature of 550-600 °C issuitable pyrolysis temperature(Onay and Kockar 2003).

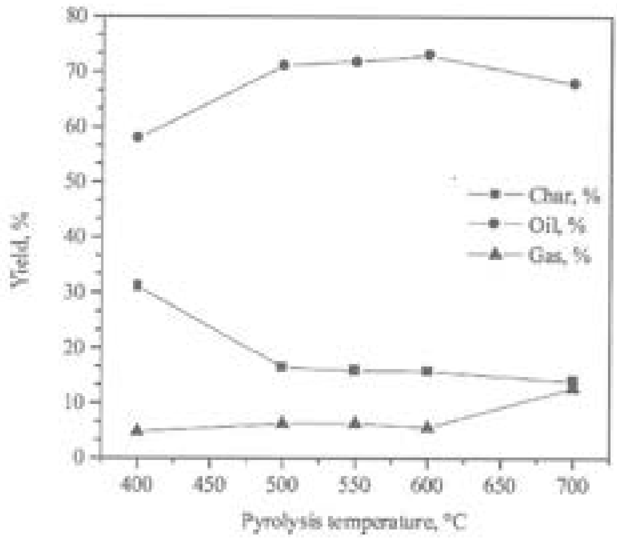

Fig. 6 The yields of flash pyrolysis products at pyrolysis temperature of 550 °C

3. Biochar production Technologies

3.1 Batch type process

The batch type process is mostly used in rural areas in the developing countries. The biochar production yield is very less near about 12 to 30% and it is construction less and no operating cost (Kammen and Lew *et al.*, 2005).The batch process for biochar production includes:

1. Earthen and mound kiln;
2. Brick, concrete and metal kiln(Panwar *et al.*, 2019).

3.1.1 Earthen and mound kiln

Duku and Hagan conducted a study on biochar production using the earthen and mound kiln. They used a wood as a feedstock during the study. The process was performed in ground pit and soil used as an insulating material. The ground pit resists the flow of air during the carbonization process. Lohr et al conducted an experiment he shows that the carbon dioxide emission into atmosphere was more near about 334ppm. The incomplete combustion of product affects the human health.Ballis conducted an experiment and he observed that the moisture content also affects the production of biochar yield in traditional process. The charcoal yield produces using the traditional method was 10 to 30% when feedstock was wood.

3.1.2 Brick, concrete and metal kiln

Pennise et al. conducted an experiment using the Brazil round brick kiln. The capacity of wood was 20,000 kg and the charcoal yield was approximately 68.9%, carbon content of 85.7% and calorific value of 29.20 KJ/g. Mwampamba et al. used wood as a raw material during the study for production of charcoal. In the experiment brick and metal kiln was used. The efficiency was 25 to 35%. Kristofferson and Bokalders conducted a study he constructed a rectangular kiln using the masonry blocks or poured concrete. The charcoal yield during the cold season and warm season was 25-30% observed.

3.2 Continuous type process

At present, the continuous biochar process is mostly used in the commercial sectors because of maximum efficiency, high yield production, and good quality. The biochar production during the study was 25 to 35% (Duku and Ben). The continuous biochar process includes:

1. Drum type pyrolyzer
2. Screw type pyrolyzer(Panwar *et al.*, 2019).

3.2.1 Drum type pyrolyzer

Robert et al. invented during the study raw material was pyrolyzed in continuous process. The horizontal mounted kiln was constructed and heated externally at 450°C. With the help of peddles continuous feeding of biomass took place in the drum. In the experiment biochar yield efficiency was increases up to 50%. Jelinek studied on drum pyrolyzer using the heating tube installed in the centre of the drum. The drum slowly rotates at temperature of 400-500 °C. The drum pyrolyzer feed material to be carbonized was located near one end of the face and discharge took place at the other end. Collin experimented on Pyrolysis recovery of raw material form special wastes. He reported that pyrolysis oil produced using the superior wastehydrocarbons such as scrap tires, cable, waste plastics. The material heated in drum reactor at temperature of 700 °C.

3.2.2 Screw type pyrolyzer

Brown and Brown developed a biochar production technology using the red oak wood biomass. They found that the flow rate gas 3.5 l/min, temperature 600 °C, and auger speed 63 RPM was required for maximum bio-oil yield and minimum char yield production. The result showed that the production of bio-oil yield was 73%. The reactor is more suitable for bio-oil production. Ferreira et al. investigated a screw reactor using the elephant grass for production of char. During the study screw reactor temperature was maintained about 400 to 600 °C. The biochar yield was maximum near about 37.4% at temperature of 400°C.

4. Physiochemical Properties of End Product of Pyrolysis

4.1 Properties of bio-oil

Theproperties of bio-oil as shown in Table 2. The solid and ash contents are 0.5 wt% and 0.25 wt%, respectively. Both of solids and ash are highly undesirable because they can bring many negative effects to the storage and combustion of the bio-oil.In the rice husk has high ash content around 15%. The metal contents in char particles from rice husk are much higher than char particles from other feedstocks (Lu Qiang *et al.*, 2008).

Table 2 : Basic fuel properties of the bio-oil (Lu Qiang *et al.*, 2008)

Fuel property	Value	Fuel property	Value
Water (wt%)	28.0	Density (g/ml, 30 °C)	1.14
pH	3.2	Flash Point (°C)	68
Solids (wt%)	0.5	Kinematic viscosity (cSt, 40 °C)	13.2
Ash (wt%)	0.25	Surface tension (mN/m, 30 °C)	35.3
Extractives (wt%)	1.3	Specific heat capacity (MJ/m^3 K)	3.178
HHV (MJ/kg)	16.5	Thermal conductivity (W/m K)	0.390

4.2 Properties of biochar

Biochar consist of fixed carbon, hydrogen, volatile compounds, moisture content and ash components as shown in Table 3. The carbon found in most organic matter and stable for long time period.The carbon in biochar is distorted during the heating process to produce fragrant structures that are highly opposed to microbial decomposition. The biochar structure mainly consists of carbon and minerals of dissimilar pore size(Qambrani *et al.*, 2017).

Table 3 : Elemental composition of biochar from different plant materials, prepared at three different temperatures (Jindo *et al.*, 2014)

Type of biochar	Pyrolysis temperature (°C)	Elemental composition (% w/w)*				Ash
		C	H	O	N	
Wood mixture	450	63.58	2.35	20.16	1.17	12.74
	500	63.84	2.21	19.04	1.11	13.80
	550	62.83	1.97	19.27	1.01	14.92
Maize	450	58.82	2.15	14.17	1.88	22.98
	500	54.97	2.05	13.75	1.95	27.28
	550	44.19	1.56	22.73	1.79	29.73
Meadow grass	450	59.38	2.44	16.67	1.78	19.73
	500	57.93	2.21	17.34	1.72	20.80
	550	55.24	1.83	17.63	1.66	23.64

5. Applications

5.1 Applications of bio-oil

The bio-oil produced from pyrolysis process has a large range of application. The major applications include heat and power generation, liquid fuels, and raw chemical products as shown in Fig.7. The produced bio-oil can be used in energy production by combustion. The heating value of bio-oil has lower as compared to fossil fuels. Bio-oil is a renewable source of energy; it produces lower emission of No_x and So_x when burned as compared to fossil fuel emission (Czernik *et al.*, 2004). The burning of bio-oil, emissions of greenhouse gases are lower than fossil fuels. During the heat generation through combustion of bio-oil is considered carbon negligible because all CO_2 is captured by the plants and tress during the photosynthesis process (Luo *et al.*, 2014). Chemicals extracted from bio-oil are used as food flavourings, resins, adhesives, agrichemicals, and fertilizers (Czernik *et al.*, 2004).

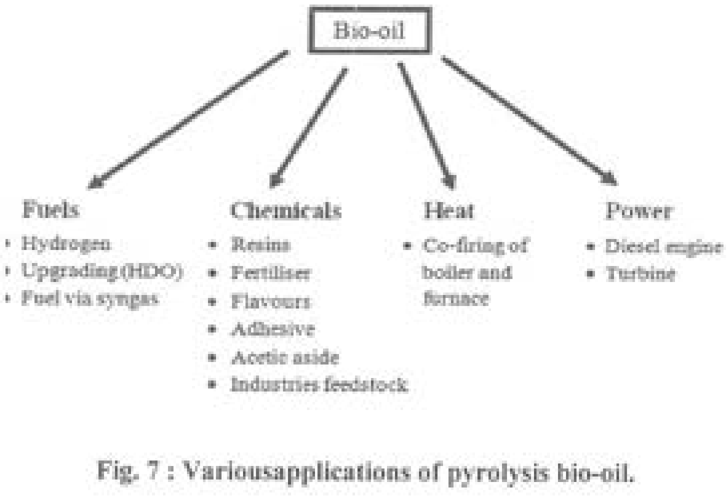

Fig. 7 : Variousapplications of pyrolysis bio-oil.

5.2 Application of biochar in Soil Improvement

Biochar potentially affects many different soil functions and ecosystem services. Biochar has a bulk density much lower than that of mineral soils and, therefore, application of biochar can reduce the overall bulk density of the soil, although increases in bulk density are also possible. The biochar which applied in soil having a low mechanical strength and disintegrates quickly into small particles that fill up existing pore spaces in the soil, Therefore the dry bulk density of the soil will increase.

The soil pore network can be affected by biochar inherent porosity as well as its other characteristics, in several ways. Biochar particle size, pore size distribution, intersconnectivity, the mechanical strength, translocation and interaction of biochar particles in the soil are becomes important factors that will lead to different outcomes in different soil-climate management combinations.Some researcher suggests that biochar application into soil may increase the overall net soil surface area and consequently, may improve soil water retention and soil aeration capacity (Verheijen*et al.*, 2003).

6. Conclusion

Pyrolysis technology is a capable by converting the lingo-cellulosic and hemi-cellulosic biomass into useful product i.e. renewable energy. Properties and products of biomass is depends on feedstock composition andstructure, and the process temperature, heating rate and residencetime.Interms of economics, the benefits are mixed and depend on feedstockcost, product yield, value of final products, and plant size.The development of pyrolysistechnologies is used to exploit their efficiency and economic and GHGbenefits.Pyrolysis is a rapidly developing technology withgreat potential but the process is essentially better suitedto producing a fuel oil, more suited to use in diesel enginesand gas turbines.

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Study of Physical, Chemical and Textural Quality Parameter of Pasta : A Review Paper

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Abstract: Pasta is a widely consumed food in all over the world. Coarse semolina obtained from durum wheat and water is the main ingredients of conventional pasta products. The amount of gluten and quality level of durum wheat are two important factors for the superiority pasta. The compositions of raw materials which are used for pasta preparation directly affect the physical, chemical and textural properties of the product. In the recent years, several ingredients and additives have been developed and are being used to improve the quality of pasta made from durum wheat. Here we analyze quality parameters and overall product quality of pasta.

Keywords: Pasta, quality, durum wheat.

1. Introduction

"Pasta" is an Italian word for "dough" [1]. Italian styleextruded foods namely spaghetti and lasagna are generallytermed as pasta. It is a primeval food which is de.ned as a typeof dough extruded or stamped into many shapes for cooking [2]. World pasta production amounts to approximately 14million tons in 2014 [3]. Traditionally, Italy is the main producerand leader of the pasta consumption in the world [1].Pasta is far and widely consumed in the globe for the reasonthat of its convenience, palatability, and the longer shelf lifethan other bakery products, such as breads and buns [4].Durum wheat (*Triticum durum*), which is the hardestwheat, is traditionally used to make pasta. Semolina, coarseparticles produced by the milling process of durum wheat, isideal for making pasta [1]. It provides pasta a good cookingquality and eating features will be better.Figure 1 shows the conventional method of durum wheatpasta production. .e important factors for the superiority of finished pasta are gluten content and quality of durum wheat. Pasta cooking quality and gluten strength are affected bythe molecular weight of glutenin. Among high molecularweight glutenin subunits, (HMWGS) HMWGS 6 + 8 or 7 + 8give better quality than HMWGS 20. Among low molecularweight glutenin subunits, (LMWGS) LMWGS gives betterquality than LMWGS 1 [5].Relatively high yellow pigment content, low lipoxygenaseactivity and high protein content are important properties ofdurum wheat for good cooking quality of pasta [6]. However,Bustos et al. [4] have reported that wheat "our from both*Triticum durum* and *Triticumaestivum*can be utilized forpasta development and the protein content of durum wheat(on average 11.81% dry weight of defatted flour) is higher thanthe protein content of bread wheat (on average 11.08% dryweight of defatted flour). Also the protein content of breadwheat has a higher variation (13.54–5.71%) than durumwheat. Moreover the total content of gliadin and glutenin ofbread wheat (61.53%) is not significantly different from thetotal content of gliadin and glutenin of durum wheat (61.42%)[7]. Carotenoids content of durum wheat is higher thanthat of bread wheat and therefore, pasta made with durumwheat shows more yellow color than bread wheat pasta [4].

Moreover, durum wheat pasta is dense and .rm in texture andshows more elastic properties.Relatively low in fat and sodium levels give a reason toconsider pasta as a healthy food [9].Its ease of use, low glycemic index and long shelf life havelead to become pasta as an interest of researchers [10]. In additionto that, pasta is a trendy food with a wide range of acceptabilityin many population groups including fitness enthusiasts[11].Increased demand by growing number of health consciousconsumers for healthy foods has shifted the interest ofresearchers and food manufacturers to develop pasta productsrich in minerals, vitamins, and with low glycemic index.Bustos et al. [4] have reported that among the functional foods,pasta is an ideal vehicle for the wellbeing advancementdepending on its low cost, long shelf life and high worldwideconsumption. World Health Organization (WHO) andFood and Drug Administration (FDA) consider pasta as anappropriate vehicle for the incorporation of nutrition supplements[12].In the recent past, the food industry has made a continuous effort to introduce newer functional pasta productsenriched with nutrients and bioactive compounds [13].

Accordingly, different grains have been utilized to substitutewheat semolina [14]. Incorporation of other grains has resultedin higher dietary benefits, such as increased essential aminoacids, minerals, vitamins and phenolic compounds. In addition,for unique sustenance composite flours have been usedto develop gluten-free or low glycemic index pasta. A fewresearches have examined the potential use of functionalingredients to produce pasta which are enriched with dietary fiber [15], bran [16], legume "our [17], whey and egg whitepowder [18], millet [19] and other plant materials [4, 19].These studies demonstrate the increasing interest of consumers to use pasta as a functional food. Addition of beneficialingredients to pasta can reduce the glycemic index and provides additional health benefits to consumers. Durum wheat, that provides the primary ingredient for pasta productionnamely semolina contributes only 5% to the total world wheatproduction and it is generally sold at a higher price than the common wheat [20].

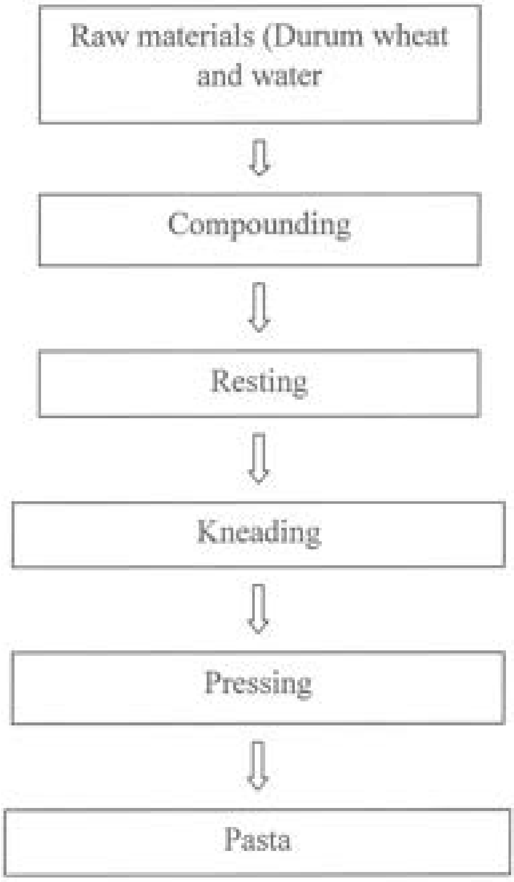

Fig 1 : ˊConventional durum wheat pasta production process [8].

2. Role of Starch and Gluten Protein on the Quality of Pasta

Compositions of raw materials which are used for pastapreparation directly affect the physical, chemical and texturalproperties of pasta [21]. Cooking quality is considered as themost important quality characteristics of pasta. Cooking time,cooking loss, water absorption index, swelling index, and textureare the parameters that determine the cooking quality[22]. Characteristics of semolina and the Maillard reactionsthat occur in food processing affect technological and sensoryproperties of pasta [23].Starch network and the gluten protein of pasta productsdetermine the quality of pasta [24]. They are related to starchcomposition and protein content of the pasta ingredients [25].Glutenin and gliadin are the two main components ofgluten.When exposed to water glutenin and gliadin form a stronggluten network which is typical for wheat flour. This glutennetwork forms uniform and compact system with swelledstarch granules during the cooking. Physical competitionbetween protein coagulation and starch swelling determinethe cooking quality and textural characteristics of pasta [26].In the event that the protein coagulation wins, starch particlesare caught in the system alveoli advancing firmness of cookedpasta. On the off chance that the starch swelling wins, theprotein coagulates in discrete masses, coming up short on aconstant system, and pasta will demonstrate non-abrasiveness and typically stickiness [9]. The associations between proteinsystem development and starch gelatinization within the sight of water are identified with various textures and cooking characteristicsof pasta [27].High resistance to breakage and cooking tolerance, whichare given by a strong gluten network are important parametersfor low cooking losses and high water absorption of pastaproducts. During the cooking, coagulation of the gluten networkreduces the elasticity and compactness of the proteinand starch system of pasta products. .Therefore the cookingloss is high due to the easy swelling of starch granules during cooking. The protein quality and content of the raw materialdetermine the level of gluten content and more than 11–16%(dry weight basis) of protein in durum wheat is not suitablefor dough formation as it is difficult to handle during the processing[8].

3. Pasta Products with Added Starch

Starch is a polymeric carbohydrate comprising of countless units of glucose joined by glycosidic bonds and it is the major energy storage of green plants. In pasta production starch is added to improve the appearance, surface smoothness, and mouth feel of the final product. According to the findings of Fiorda et al. [70-28] greater stickiness can be observed due to the high amylopectin content which influences the texture of the products after adding starch to the pasta formulations. A preliminary study conducted by Ibitoye et al. [84-29] has investigated sweet potato starch and wheat flour blended noodles. Results have demonstrated that there is no any significant difference of overall acceptability between noodles which contained 30% potato starch and conventional formula. Menon et al. [30] have studied the effect of various sources of starch such as banana, lentil, black gram and sweet potato on pasta quality. Among the starches, highest cooking loss has been observed in pasta fortified with 10% lentil starch. Crude protein contents have been higher for black gram and sweet potato starch-fortified pasta samples. Firmness of cooked pasta has been higher for black gram starch fortification, while highest toughness has been recorded for lentil starch based cooked samples.

4. Pasta Production with Composite Flour

Wheat flour which is mixed with other flour for different purposes called as composite flour. Legumes, yam, maize, soybean, sweet potato, and cassava flour are widely used to prepare composite flour. Several researchers have studied the use of composite flour in pasta making. The micronization is a process that reduces the particle size of ingredients to increase the solubility or bioavailability of particles. Junqueira et al. [31] have evaluated the impact of using wheat semolina and micronized corn pericarp in spaghetti type pasta. It has significantly contributed to the protein, ash, carbohydrate, and cooking loss of pasta. However, the moisture content, lipid content, caloric value, cooking time, weight gain, and volume increase parameters have not been significantly affected. Bouasla et al. [32] have carried out a study to develop precooked rice pasta enriched with legume flours (yellow pea, chick pea and lentil) in order to produce gluten free spaghetti type pasta product. Legumes are rich source of proteins, fibers, vitamins, and minerals when compared with other flour types. According to the findings, incorporation of legume flour decreases expansion ratio and lightness, and increases yellowness, firmness, and adhesiveness, without affecting the minimal preparation time. Incorporation of amaranth flour in processing of pasta has produced a low level of stickiness that is more desirable for the pasta products [33].

Ginting and Yulifianti [34] have studied characteristics of noodle prepared from orange-fleshed sweet potato and bread wheat flour. The results have suggested that starch characteristics such as swelling power, pasting properties and amylose-amylopectin ratio are affected to the noodle texture other than the gluten protein content of wheat flour. Low glycemic index is an important factor of a diet for both healthy and diabetic subjects. Generally, seeds of legumes give moderate postprandial blood glucose increase [35] and Goni and Valentın-Gamazo [11] have observed that the addition of chickpea flour decreases the glycemic response of pasta in healthy people. Results have demonstrated that combination of wheat and chickpea enhances the level of quality protein in pasta products as legumes are rich in lysine which is a limiting amino acid in cereal and cereals are rich in methionine which is a limiting amino acid in legumes. Pasta products which contained chickpea flour have presented a low glycemic response. This can help widen the scope of low GI foods accessible to the consumer. Gull et al. [36] have studied the optimization and functionality of millet supplemented pasta. According to the results millet flour cause significant increase in cooking loss because of the low gluten level results in poor protein network. According to the findings of Cárdenas-Hernández et al. [14] incorporation of flour from dried amaranth leaves and amaranth seed decreased the cooking time and increased the cooking loss percentage. Peanut flour is low fat, high protein functional ingredient which is prepared from defatted roasted peanut kernels. Howard and Hung [37] have formulated pasta with peanut flour. Potential positive attributes of peanut pasta include its unique flavor, whereas a potential negative attribute seems to be its softer texture upon cooking. Lorusso et al. [38] have investigated the use of fermented quinoa flour for pasta making. Quinoa is a pseudo-cereal which has a high-protein content (14–16 g/100 g) [39]. Its amino acid composition, and highamount of histidine and lysine, are near to the perfect protein balance recommended by the FAO [12]. Addition of 20% (w/w) of quinoa flour to semolina has been productive in enhancing the dietary attributes without affecting the sensory and technological quality of pasta. Moreover, the study has revealed that fermentation of quinoa flour with lactic acid bacteria can additionally improve the beneficial outcomes of quinoa. As indicated by this research it can be concluded that the nutritional potential of pasta can be successfully improved through the fermentation technology of ingredients. This is reasonable to be incorporated into the future food propensities improvement. The commonly used potential sources for composite flour in pasta production are presented in Table 1.

Table 5 : Potential sources for composite flour in pasta production. Orange fleshed sweet potato flour Amaranth flour [14, 28]

Source of flour	References
Orange fleshed sweet potato flour	[40]
Legumes	[11, 41]
Finger millet flour	[19]
Peanut flour	[91-42]
Quinoa flour	[92-43]

Conclusion

Pasta is a staple food in many countries all over the world. Though pasta is simple and easy to produce, the cost of main ingredient durum wheat semolina is significant in popularizing pasta. Many research studies have been conducted around the world to develop pasta products with nonconventional ingredients and added functional properties to meet the demand of health conscious consumers. The compositions of raw materials which are used for the pasta preparation directly affect the physical, chemical and textural properties.

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Biochar Based Green Catalysts for Biomass Conversion

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Abstract: Lignocellulosic biomass is utilized for the production of biofuels and chemicals; however, the high cost of conversion technologies hinders its use as an economical alternative. Therefore, several efforts have been taken towards biomass conversion to valuable products using several (bio) catalytic. Efficient catalyst is the key to the development of next-generation technologies of converting biomass into value-added fuels. However, designing biomass catalysts based on earth-abundant metals that can work under mild conditions (e.g., low pressure, low temperature, and with green solvents) remains a challenge. The use of a supported heterogeneous catalyst makes the process more efficient and economically feasible in many applications. Biochar (carbon) materials have been extensively applied as efficient catalyst supports form any reactions because of their good mechanical strength, high chemical stability, large surface area, inbuilt porous structure and surface chemistry. Metal and precious metal catalysts are widely used in the supported forms of porous biochar for many applications. The use of carbon as the support for metals, rather than other supports material (e.g. silica, alumina) facilitates recovery of the metal, which is achieved by simply burning the catalyst.

Keywords: Biochar, biomass, catalyst, activation, pyrolysis

1. Introduction

Fossil fuel such as coal, natural gas, and petroleum for the majority of energy demand. Rapid consumption of fossil fuels as a result of rapid civilization and industrialization has culminated in depletion of these energy supplies and degradation of the atmosphere, resulting in significant problems such as global warming and climate change. This has created serious concern about the production and usage of renewable energies to mitigate the impact of fossil fuel use (Bhanja & Bhaumik, 2016). The demand for renewable fuels will keep increasing in near future to mitigate serious environmental issues like CO_2 emission which is the key factor for the cause of global warming. Biomass energy is one of the most suitable substitutes to replace fossil fuels. Lignocellulosic biomass is a valuable source for the production of biofuels and chemicals. However, due to its compositional characteristics, economically converting biomass feedstock into sustainable energy is a challenging task (Hongbo Du, Fang Deng, Raghava R. Kommalapati, 2020). The thermochemical conversion technique is used to convert biomass for producing various energy forms such as syngas, bio-oils, and biochar (Ma et al., 2012). The suitable catalyst is used during the conversion process to overcome limitations such as high dispersion and poor yield or degradation (Collard & Blin, 2014; Patwardhan et al., 2011). Biochar is carbon-rich material obtained through the thermochemical conversion of biomass. Biochar is characterized by the large surface area which makes it suitable to be used as catalyst or catalyst support (Bazargan et al., 2015; Liu et al., 2014, 2015) and considered as a green catalyst that has high-end application in chemical synthesis, biodiesel production, environmental protection apart from soil remediation (Xiong et al., 2017). The present paper discusses biochar as a catalyst, its production, up-gradation and application in the different conversion process.

2. Biochar

Biochar is produced by the heating of biomass at high temperature in the absence or limited oxygen supply. Pyrolysis and hydrothermal carbonization are common methods used for biochar production which can be used for different applications as shown in Figure 1. Biochar yield (solid) through the different process are depicted in Table 1.

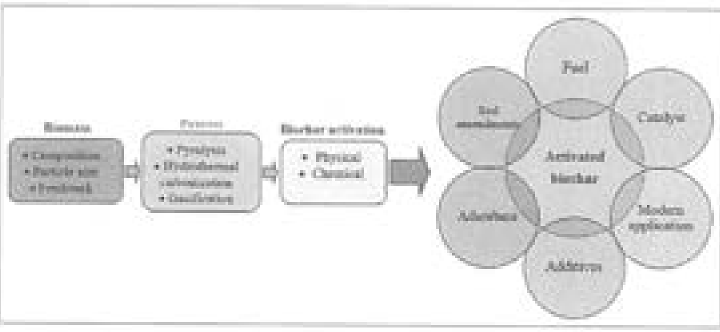

Figure 1: Biochar production techniques and its application

Pyrolysis

Pyrolysis is a thermochemical decomposition of biomass at a higher temperature in the range 300-650 °C in an oxygen-deficient environment. This results in the formation of carbon enriched solid product called biochar along with other products like bio-oil and gases (CO, CO_2, CH_4 and H_2) (Mohan et al., 2006). Slow pyrolysis which is taking place at 300-650 °C with long residence time and low heating rates of 10-30 °C/min, is related to a higher yield of solid biochar in the range of 25-35% compared to fast pyrolysis and flash pyrolysis (Brownsort & Mašek, 2009; Mohan et al., 2006).

Hydrothermal carbonization

Hydrothermal carbonization (HTC) is wet torrefaction that converts organic feedstock into the carbon-rich solid product at temperature range 180-260 °C taking place in liquid phase generally water under pressure of 2-6 MPa for 5 to 240 min (Hoekman et al., 2013; Libra et al., 2011). The process is carried out in presence of water therefore not affected by the high moisture content of feedstock and eliminated pre-drying requirement of the wet biomass (Benavente et al., 2015). The process forms solid char (hydro-char) which has a mass yield of about 40-70% along with liquid (bio-oil) and a small fraction of gases (W. Yan et al., 2010) depending on the process conditions.

Dry torrefaction

This is a mild pyrolysis process in an inert atmosphere at 200-300 °C and a residence time of 30 min to a few hours (Pimchuai et al., 2010; Rousset et al., 2012). Torrefied biomass, on the other hand, is not called ideal biochar because it contains certain volatiles and has properties that come somewhere between raw biomass and biochar (Kambo & Dutta, 2015).

Gasification

Gasification is partial oxidation of biomass at a high temperature 600-1200 °C with a limited supply of air (McKendry, 2002). Gasification results in the generation of syngas (CO, H_2 and CO_2) and a small amount of biochar as byproduct < 10% (Brewer et al., 2009; Bridgwater, 1995).

Table 1: Biochar production form different process (Kambo & Dutta, 2015)

Process	Temperature, °C	Residence time	Heating rate	Product yield, (%)		
				Solid	Liquid	Gases
Slow pyrolysis	300-650	5 min-12 h	10-30oC/min	25-35	20-30	25-35
Gasification	600-900	10-20s	50-100 oC/s	<10	<5	>85
Dry torrefaction	200-300	30 min- h	10-15 oC/min	60-80	-	20-40
HTC	180-260	5 min-12 h	5-10 oC/min	45-70	5-25	2-5

* Hydrothermal carbonization

3. Activation and functionalization of biochar

Biochar obtained through the pyrolysis process has a lower specific surface area, poor porosity and limited surface functional groups (Liu et al., 2015) which may limit the degree of application of biochar as a catalyst or catalyst support (Cao et al., 2017). These disadvantages can be overcome by the method of activation or functionalization process (Cha et al., 2016; Kambo & Dutta, 2015).

Biochar activation

Biochar is activated to increase its specific surface area and porosity. The activation process aids in the development and opening of biochar's internal pore structure (Kambo & Dutta, 2015). Activated biochar can be used as activated carbon, in soil amendments, sequestration agent and environmental adsorbent (Cha et al., 2016; Liu et al., 2015). Physical activation and chemical activation method are generally used for the activation of biochar. Physical activation is carried out at a higher temperature above 700 °C under the controlled flow of steam or carbon dioxide (CO_2) or a mixture of both (Cao et al., 2017). During activation, enclosed pores in the biochar matrix are opened and interpreted with other pores, and highly reactive carbon parts are removed (Liu et al., 2015) and specific surface area is increased significantly with the microporous structure which is more prominent than mesopores (Jimenez-Cordero et al., 2015; Shim et al., 2015). It has been reported that steam activation at 800 oC for 45 minutes increased the surface area of biochar produced by fast pyrolysis from less than 5 m2/g to 136-793 m2/g for various substrates. (Lima et al., 2010). When activation agent steam and CO_2 were used for activation of biochar prepared by slow pyrolysis, the surface area and porosity showed significant increment to 840.6 m^2/g in the case of steam whereas 512.0 m^2/g in the case of CO_2 compared to the surface area of raw biochar (Kołtowski et al., 2017).

Chemical activation

Chemical activation is carried by impregnation technique using a solution of activation agent such as KOH, $ZnCl_2$, K_2CO_3, H_2SO_4, H_3PO_4 and likewise. It is then heated at a higher temperature under inert gas flow (Cao et al., 2017; Cha et al., 2016;

Yorgun & Yildiz, 2015). These chemicals help in the development of pores by removing partial carbon atoms from the biochar matrix (Azargohar & Dalai, 2008). Chemical activation is more efficient than physical activation because it produces more surface area and porosity (Kambo & Dutta, 2015). The investigation carried on biochar electrosorption impregnation with KOH solution at activation temperature of 675 °C and 1000 °C revealed that the surface area of biochar increased from 1.66 m^2/g to 614-990 m^2/g (Dehkhoda et al., 2014).

Biochar functionalization

Biochar's unique properties are brought together by functionalization, which allows it to achieve desirable catalytic capacity through surface modification or active substance deposition (Li et al., 2014; Liu et al., 2014). This is usually accomplished by introducing a specific functional group, such as an acid group, onto the surface of biochar. Sulfonation with concentrated H_2SO_4 or its derivatives (Konwar et al., 2014; Liu et al., 2015) or weak acid groups like –COOH group (Qi et al., 2014) is the common method used.

4. Catalytic applications of biochar

Biochar is carbonaceous material inexpensive, environmentally friendly and can be produced easily. It can be used as a catalyst alternative to carbonaceous material or as a catalyst support in the industrial application (Lee et al., 2017; Liu et al., 2015). Biochar is used as a catalyst in biomass hydrolysis and dehydration, biodiesel production, up-gradation of bio-oil, and thermochemical conversion of biomass such as pyrolysis and gasification

Hydrolysis

Biomass contains biopolymers such as cellulose and hemicellulose that can be converted into useful compounds such as sugars, furfural, and 5-hydroxymethylfurfural (Zhou et al., 2011). The process carried out using hydrolysis agents such as enzymes, mineral acids, and solid acids to hydrolyze biomass. Enzymatic hydrolysis is expensive and time-consuming, whereas the use of mineral acids is hazardous to the environment. Because of its high reactivity, recyclability, and lower cost, biochar-based solid acid is seen as a viable alternative to mineral acid in hydrolysis and dehydration (Bai et al., 2015; Lee et al., 2017)

Biodiesel production

Biodiesel is produced through the transesterification of vegetable oil or animal fat feedstock, as well as other non-edible raw materials like frying oil. Acidic or basic catalysts can catalyse the transesterification and esterification reactions. Several homogeneous and heterogeneous catalysts have been used for biodiesel production. Activated biochar can be used as good heterogeneous acid or base catalysts such as CaO/ biochar, KOH/biochar, K_2CO_3/biochar, etc are used for biodiesel production (Cao et al., 2017; Konwar et al., 2014) which can be obtained from the various biomass resources, such as wood, glucose, starch, etc., can be used as solid acid catalysts in biodiesel production (Li et al., 2014). Base activated biochar catalysts are found efficient for the transesterification reaction of triacetin with methanol (Wang et al., 2017). Despite the high yield of biodiesel produced from the vegetable oils or animal fats under the catalysis of the fresh acid or base-functionalized biochar catalysts, most of these biochar-based catalysts get deactivated after several recycling cycles (Escobar et al., 2009). Therefore, the stability of the acid and base-functionalized biochar catalysts needs to be significantly improved to maximize their lifetime.

Pyrolysis and gasification

Biochar can be used as a support material for metal and metal oxide. Oxygen-containing groups in biomass matrix adsorb metal cations during the preloading process (Liu et al., 2014, 2015; Richardson et al., 2010). Metal precursor-like Ni_2+; Cu_2+, Mg_2+ forming metal particles can be loaded onto the surface of the biochar and used in pyrolysis (Liu et al., 2014, 2015). Biochar supported catalyst also used in syngas generation and conversion of tar in pyrolysis (Richardson et al., 2010; Q. Yan et al., 2013). Biochar supported Ni catalyst is effective in hydrogen production from biomass gasification (Yao et al., 2016) and generally prepared by impregnation method.

5. Conclusion

Biochar produced from biomass is a promising green catalyst and catalyst support to be used in several applications such as chemical synthesis, biofuel production. Biochar is a sustainable and low-cost catalyst that can be used as an alternative to conventional or commercial catalysts. The inherent properties of biochar such as surface area, porosity are advantageous in modifying as per requirement using the activation method. It works as a support for alkali and metal catalyst by introducing functional group or substances into the activated biochar and can be used for biomass up-gradation such as hydrolysis and dehydration, biodiesel production, biomass pyrolysis and gasification

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PKV Mini Dal Mill a Boon for Agro Processing Centre

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Abstract: The study was conducted by AICRP on PHT, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to enhance entrepreneurship in unemployed educated youths in Vidharbha region of Maharashtra. A new Agro Processing centre (APC) was established at Jamthi (Hatgaon), Tq. Murtizapur, Distt Akola (Maharashtra) for Farmer's cooperative society i.e. Krishi Vikas Shetkari Audhogik Sahakari Sasntha. PKV mini dal mill was installed at this APC. PKV mini dal mill gives the recovery of nearly 72 to 75% and 25 to 28 % byproduct (brokens+husk+powder).Also this dal mill was efficient in preparing mong dal (75-80% recovery) from Green gram and udad dal (75-80% recovery) from Black gram. After installing of PKV mini dal mill at APC the centre generated an income of about Rs. 1,46,650/- and the profit gained was Rs. 1,32,318 during 2010. And during 2011 the centre generated an income of about Rs. 2,71,250 /- and the profit gained was Rs. 2,24,586. The study showed that the entrepreneur who is effectively maintaining PKV mini dal mill at his Agro Processing Centre (APC) had generated sufficient income by processing and value addition of pegion pea and this centre is now become an ideal for other farmers who are willing to become an entrepreneur. Post harvest processing is one of the necessary steps in conversion, value addition and prevention of loss of agricultural produce. It is essential operation being carried out prior to consumption of agro produce. Most of the post harvest processing operations are performed at urban side resulting into increased cost of transportation and storage requirement besides loss of some important byproducts and post harvest losses. These operations include threshing, cleaning, grading, drying, and storage, which can be treated as primary processing of the farm produce. Operations like de-husking, grinding, de-cortication, milling, oil extraction, use of by- products etc. are the secondary processing operation. Primary or secondary processing of agricultural produce at village level will help to reduce the cost of processed material, giving additional income source to producer, employment generation among the rural youths and in situ value addition. As a result, processed product will be available at lower cost for the rural population also.

It is now necessary to assess the potential for these processing operations at village level. This will generate data for design of model / pilot plant/agro processing centre, which in turn can be installed befitting to the needs of the production locality. Such models / pilot plant/agro processing centre will attract the farmers/village artisans, villagers, unemployed youths and rural entrepreneurs to adopt by themselves for producing value added products. Therefore, the Agro Processing Centres are needed to be established at production catchments. The study was undertaken with the objectives to establish one new Agro-processing centre on cereals and pulses and to monitoring the performance of Agro Processing Centre.

Materials and Methods

Project proposal was finalized and the beneficiary was selected. The selection committee had selected the Farmer's cooperative society i.e. Krishi Vikas Shetkari Audhogik Sahakari Sasntha, Jamthi (Hatgaon) Tq. Murtizapur Distt Akola (Maharashtra) for establishment of Agro Processing Centre (APC). About 4500 farmers from 155 villages of two districts are the member of the society. Total land holding of the group is about 40,000 ha and green gram, black gram, pigeon pea are the major crop grown. The society use to sell the farm produce to the organized group of marketing at Nanded. After doing the survey it was observed that, the group can fetch higher price to their produce merely by cleaning , grading and processing of pulses into dal thus enhancing the profit. Further, the seasonal activity of shevai making can generate employment and enhance income.

As green gram, black gram, bengal gram and pigeon pea are the major crops grown and huge quantity is produce, thus, there is good scope for establishment of new Agro Processing centre. Crop wise production is shown below.

Table 1 : Cropwise production of farmer's cooperative society (2010)

Sr. No.	Crop	Production, q
1	Pigeon pea	35,000
2	Green gram	20,000
3	Black gram	100
4	Chick pea	10,000
Total		65,100

According to the crop production shown in Table 1, the machineries were selected for establishment APC Plate 1, 2 and 3. Details of machineries are given in Table 2.

Table 2 : List of Machinery for Agro Processing Centre at Jamthi (Hatgaon)

Name of Technology	Name of Machinery	No. of units required	Capacity, q/day	Power required (HP)	Rate of units, Rs. (in lakh)	Total Cost, Rs. (in lakh)
Cleaning/ grading	PKV cleaner/ grader cum polisher	03	30	1	0.30	0.90
Dal milling	PKV mini dal mill	03	10	2	0.50	1.50
	Sheller	03	10	5	0.20	0.60
Shevai	Shevai machine	03	01	2	0.30	0.90
	Plat form weighing balance	01			0.30	0.30
Civil work (foundation and drying yard)						0.90
Total		13			-	4.50

Plate 1 : Installation of PKV mini dal mill

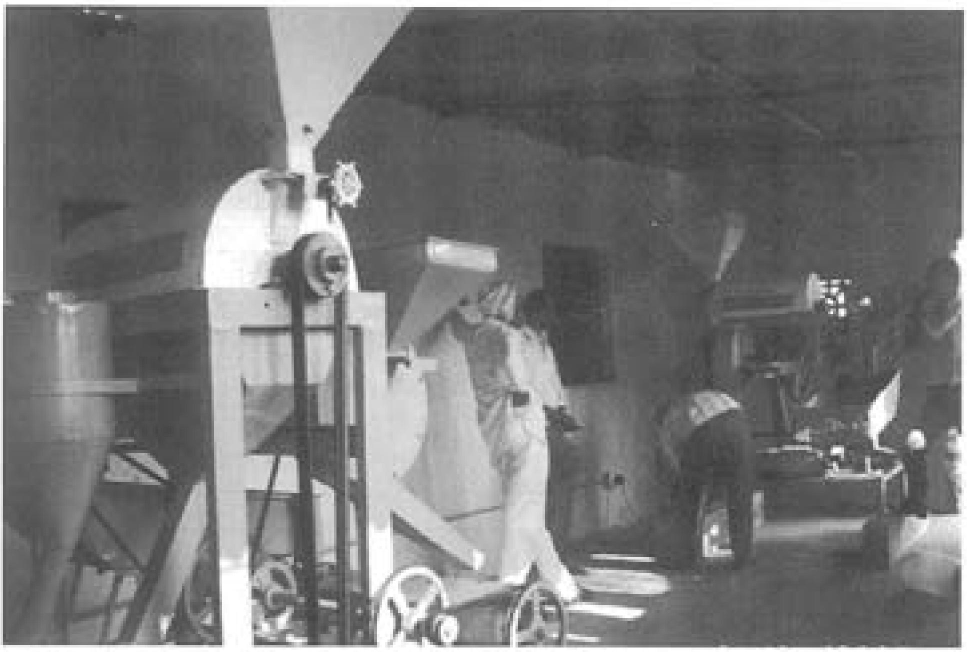

Plate 2 : PKV cleaner cum grader

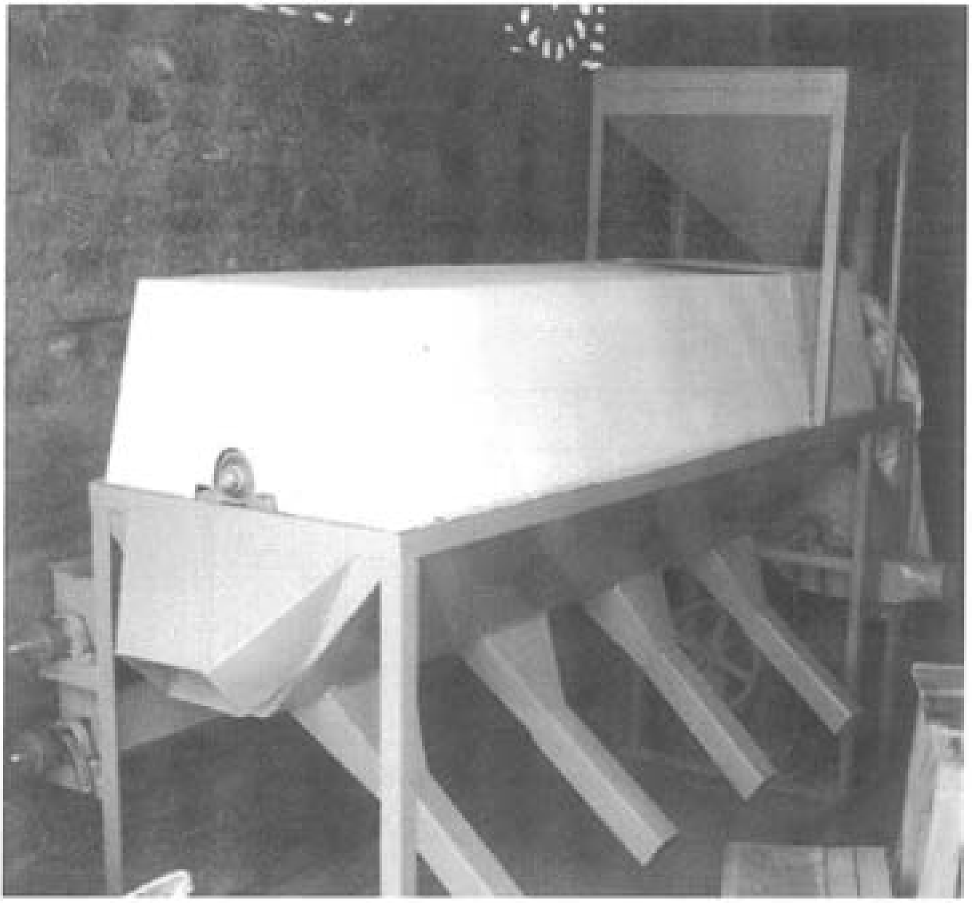

Plate 3. Installation of Shevai machine

Results and Discussion

a) Monitoring Performance of Agro Processing Centre (Jamthi) during 2010 & 2011

As per the project report the machineries were procured and installed. The working of mini dal mill and shevai machine was explained. To built up working confidence, demonstration and training to the working persons and members of co-operative society was organized. Performance of APC during 2010 (Table 3) and 2011 (Table 4) and Plate 4.

Table 3 : Performance of Activities at APC, 2010

Sr. No.	Machine	Commodity Processed	Quantity Processed, q	Charges, Rs/q	Amount collected, Rs.
1.	PKV mini dal mill	i) Pigeon pea	381	350	1,33,350
		ii) Black gram	17	200	3,400
		iii) Green gram	32	200	6,400
		iv) Bengal gram	-	-	-
2.	Sewai machine	i) Sewai processing	5	700	3,500
Total			**235**		**1,46,650**

Table 4 : Performance of Activities at APC, 2011

Sr. No.	Machine	Commodity Processed	Quantity Processed, q	Charges Rs./q	Amount collected, Rs.
1.	PKV mini dal mill	i) Pigeon pea	682	350	2,38,700
		ii) Black gram	-	-	
		iii) Green gram	23	350	8,050
		iv) Bengal gram	57	350	19,950
2.	Sewai machine	i) Sewai processing	6.5	700	4,550
Total			**768.5**		**2,71,250**

As the centre was newly established in 2010, the processing at the centre was below expectation level ,processed quantity is 235 q only and income earned was Rs. 1,46,650(Table 3), and during this season progress is satisfactory, the processed quantity is 768.5 q only and income is Rs.2,71,250/-(Table 4) The centre was used to impart trainings and demonstrations to farmers and entrepreneurs to encourage them to establish such type of Agro Processing Centres in their respective production catchment. About 22 entrepreneurs and 77 farmers participated in 6 training programmes and nearly 123 farmers had participated in 6 demonstrations programs arranged at APC and Plate 5.

Table 5 : Operational performance and income generation at APC

Sr. No.	Activities	Processed material (q)		Cost of Process (Rs./q)		Expenditure incurred (Rs.)		Income (Rs.)		Profit/ Loss (Rs.)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
1	Pigeon pea	381	682	350	350	2263 (E) 3959 (O) 5000 (L) 11,222	11,935 (E) 14,915 (O) 14,700 (L) 41,550	1,33,350	2,38,700	1,22,128	1,97,150
2	Black gram	17	-	200	-	213 (E) 372 (O) 500 (L) 1,085		3,400	-	2,315	-
3	Green gram	32	23	200	350	400 (E) 700 (O) 800 (L) 1,900	403 (E) 503 (O) 600 (L) 1,506	6,400	8,050	4500	6,544
4	Bengal gram	-	57	-	350		998 (E) 1,247 (O) 1,200 (L) 3445	-	19,950	-	16,505
5	Sewai Processing	5	6.5	700	700	125 (E) 125	163 (E) 163	3,500	4,550	3,375	4,387
Total		235	768.5			14,332	46,664	1,46,650	2,71,250	1,32,318	2,24,586

Plate 4 : Processed Dal at APC

Plate 5. Entrepreneurship development through Agro Processing Centre

Conclusion

1. Agro Processing Centre during 2010 had earned income of about Rs. 1,46,650/- and gained profit of Rs. 1,32,318 (Table 3 & Table 5).
2. The centre during 2011 had earned income of about Rs. 2,71,250 /- and the gained profit of Rs. 2,24,586 (Table 4 & Table 5).
3. The centre is running successfully with the efficiency of PKV mini dal mill as 75-77% efficiency.

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Sustainable Rural Livelihood With Renewable Energy Appliances In Punjab State

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Abstract : There are abundant possibilities for the utilization of renewable energy appliances. Solar energy, an inexhaustible source, capable of meeting a significant portion of human energy needs with a minimum of adverse environmental consequences, is the most promising of the unconventional energy sources. The renewable energy appliances that are appropriate at the rural level are solar passive heating gadgets like solar cookers, solar water heaters, solar dryers, solar desalination, solar photovoltaic based gadgets like solar lantern, solar home lighting system, solar street light, solar water pump, solar inverters, the biomass-based cook-stoves, gasifiers for direct thermal applications and bio-gas plants at domestic as well as at large scale i.e. at dairy farms, poultry farms, stray cattle yards or 'gaushala's' etc. Biomass-based cook-stoves can be used where appropriate feedstock is available. To meet the energy requirement and uplifting the rural livelihood, renewable energy is one of the options. Considerable government incentives and provisions of cash payments in a phased manner have been earmarked for popularizing these among the rural masses. But due to certain techno-socio-economic reasons, discussed in the paper, these appliances have slowly been accepted by rural people.

Keywords: Renewable, Sustainable, Energy, Solar, Biomass, Appliances.

1. Introduction

Punjab, land of five rivers, is land locked state of Independent India. The present Punjab is inhabited by 2.77 crore people with 62.52 per cent living in 12581 villages. The per capita income at current prices of Punjab is Rs.1,54,966/- whereas Rs.1,26,406/- is at national level. The total cropped area of Punjab is at 78.57 lakh hectares with 41.19 lakh hectares of net area sown making cropping intensity of 190.7 per cent whereas of union of India, the total cropped area of 1983.60 lakh hectares of 1401.306 lakh hectares net area sown with cropping intensity of 141.5 per cent [3]. In recent years a stagnant productivity has been observed mainly due to falling fertility of the soil due to excessive use of fertilisers and pesticides over the years. Another worry is the rapidly falling water table on which almost 90% of the agriculture depends; alarming drops have been witnessed in recent years [11]. With the agriculture of the state being almost at par with various developed countries with consequential pros and cons, there is not much improvement in livelihood security at rural household as a whole. With the large scale burning of crop residue along with ongoing problems, the situation worsens day by day. Today, the society is experiencing a transmutation and alteration due to climate change concerns, crude oil price fluctuations in world vis-a-vis with country, increased electricity and fuel demand for raising living standards epitomized shift to renewable and sustainable use of available resources.

Renewable energy sources such as solar and biomass are emerging as viable options for meeting energy requirements of various sectors especially at rural level in an economically, environmentally and sustainable way. During the previous years, adequate infrastructure has been developed in the country as well as in state for carrying out research/development, testing, demonstration, manufacture and sell different renewable energy gadgets. Ministry of new and renewable energy of government of India, state energy development agencies, state agricultural universities, state departments and private entrepreneurs and companies are encouraging development and promotion of all available types of renewable energy gadgets [16].

There is an urgent requirement of energy security for everyone especially at rural level. Renewable energy sources and appliances are therefore, not only increasingly more relevant but also call upon us to attempt maximize and generalize their use as quickly as economically viable to each one. This paper symbolizes the potential usability, economics and government incentives for popularizing the renewable energy gadgets for sustaining rural livelihood in Punjab state as a whole.

2. Solar Energy Gadgets

Solar energy experienced by us as heat and light can be used through two routes: thermal and photovoltaic. The thermal route uses sun's heat for water heating, cooking, drying, water desalination etc. and the photovoltaic route transform the light energy of sun in to electric energy through different gadgets which further can be used for lighting, water pumping and power requirements etc.

2.1 Solar water heating systems

The solar water heating systems are based on different systems for heating water with or without heat exchanger type, heating of working fluid or direct water type, natural convection pressurised type, natural convection non-pressurised type, forced convection type, etc. The natural convection or thermosiphon type systems are the simplest and economical. These systems are suitable for domestic and small institutions. The solar water heating system work well during sunny days. In case of prolonged foggy or cloudy condition, there is a provision of heating water with auxiliary electrical supply. These systems can installed on the rooftops of houses or at any obstruction free areas near the usage point. The solar collector's inclination with horizontal surface is fixed at 45° with south facing. The common commercial models; flat plate collector (FPC) type, Fig. 1, and evacuated tube collector (ETC) type, Fig. 2, heat water upto 80°C temperature in a sunny day. For hot water requirement up to 80° C, these gadgets can be used.

Fig. 1 : The flat plate collector type device

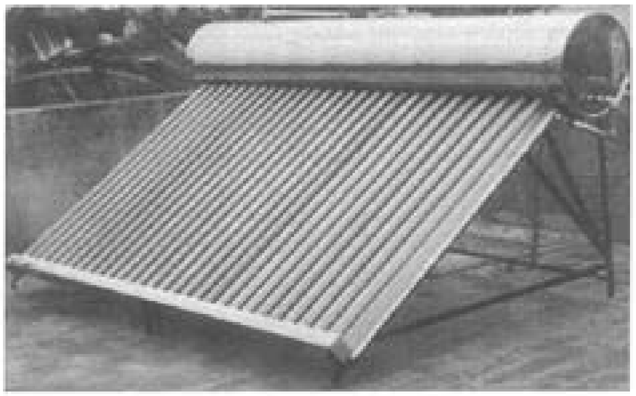

Fig. 2 : The evacuated tube collector type device

Wide spread utilization of solar water heaters can reduce a significant portion of the conventional energy being used for heating water in homes, factories and other commercial and institutional establishments. A fuel savings with 100 litres capacity gadget can be made on replacing an electric geyser for residential use and saves 1500 units of electricity annually. Environmental benefits of using a 100 litres capacity gadget can prevent emission of 1.5 tonnes of carbon dioxide per year. A life of 15 to 20 years is expected with normal use. The cost and central financial assistance on the gadget is given in Table 1.

Table 1 : The approximate cost and central financial assistance on different type of gadgets.

Sr. No.	Type of system	Approximate cost	Subsidy
1.	Flat plate collector type	Rs.22000/- for 100 LPD*	Rs.6600/- for 100 LPD*
2.	Evacuated tube collector type	Rs.15000/- for 100 LPD*	Rs.4500/- for 100 LPD*

*Liters of hot water provided per day at 60-70C

The overall financial assistance is 30 % of the benchmark cost of the gadgets and Rs.110-150 per installed litre for higher capacity systems. The payback period is 3-4 years when electricity is replaced, 4-5 years when furnace oil is replaced and 5-6 years when coal is replaced [15].

2.2 Solar cookers

Box type solar cookers are suitable for the boiling type of cooking. The cooking temperature is around 100°C. The solar cookers can be single or multi-reflector type or concentrating type. A rectangular type solar cooker for domestic use is shown in Fig. 3.

2.3 Solar dryers

Solar drying is the oldest method of food articles preservation. The different type of dryer are given below.

2.3.1 Domestic solar dryer: Most of the products used in domestic kitchen are in powder form, e.g. chilies, garlic, ginger, mango powder, coriander, onion, fenugreek leaves etc., are used in small quantities of the order of a few kilograms per year. It has aperture area of 0.36 m^2 and it is capable of drying about 2-3 kg of fresh product in 2-3 days. The domestic solar dryer is shown in Fig.4.

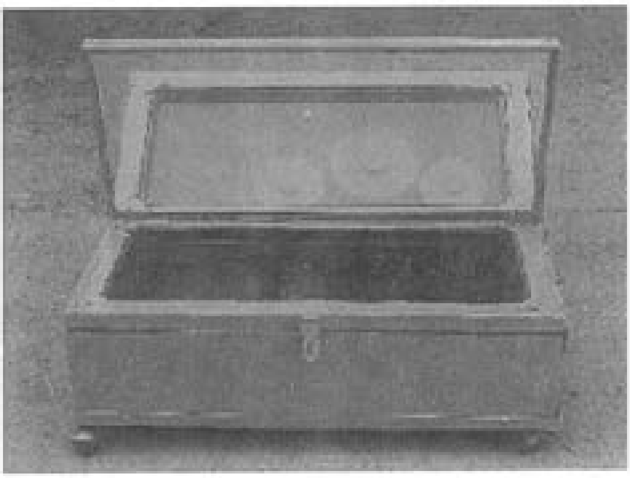

Fig. 3 : The rectangular solar cooker.

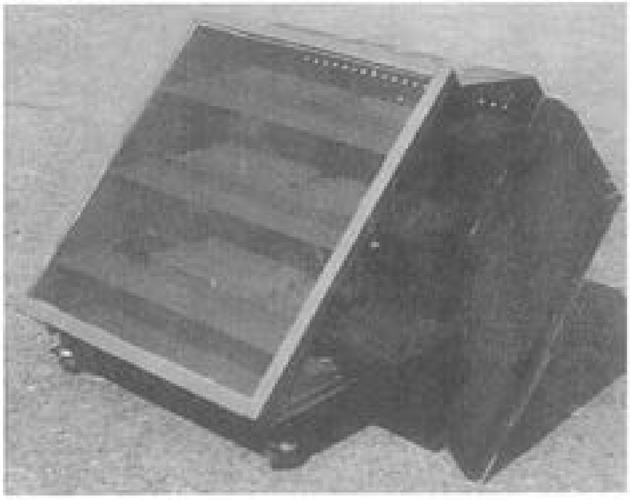

Fig. 4 : Domestic solar dryer.

2.3.2 Multi-product solar dryer: The drying air temperature is maintained below maximum permissible temperature limit, to maintain product quality, of drying product. The multi-product solar dryer, Fig. 5, is modular in design and one module of this dryer has loading capacity of 20-30 kg of agricultural product.

Fig. 5 : Multi-product solar dryer.

2.4 Solar lantern

This is an emergency light charged, as shown in Fig. 6, with sunlight and works for 3 to 4 hours. The approximate cost of the gadget varies from Rs.500/- to Rs.1800/- depending upon light intensity and panel power.

2.5 Solar home lighting system

The system consist of one 37 watt capacity solar panel, one 40 Ah battery, one charge controller, one fan and two lights, Fig. 7. It works for 4 to 6 hours. The approximate cost of the gadget varies from Rs.6,000/- to Rs.12,000/- depending upon work required.

Fig. 6: Solar lantern.

Fig. 7: Solar home lighting system.

2.6 Solar street light

The gadget consists of one 40 W_p capacity solar panel, one 12V/26Ah battery and one LED light source/bulb of 9 to 18 watts, Fig. 8. It automatically works from sunset to sunrise. It has inbuilt controller for the activity. The approximate cost of the gadget varies from Rs.13,000/- to Rs.22,000/- depending upon power of light required.

2.7 Solar water pump

The gadget earlier comprised 1600 to 2400 watt DC motor and equal power solar panels. It now comes with AC motor, Fig. 9. The power available varies from 1600 watts to 7500 watts. The discharge pipe or bore diameter varies from 2 inches to 4 inches. The pump discharge varies from 1,20,000 liters to 3,60,000 liters and works satisfactorily at 35 to 90 feet water level. The approximate cost of the gadget varies from Rs.2,30,000/- to Rs.12,00,000/- depending on pump power and discharge depth requirements. Under PM-KUSUM scheme Government of India and of Punjab will provide 30% & 50% subsidy respectively on installation of 3, 5, 7.5 & 10 HP capacity grid connected and off-grid solar pumps.

Fig. 8 : Solar street light

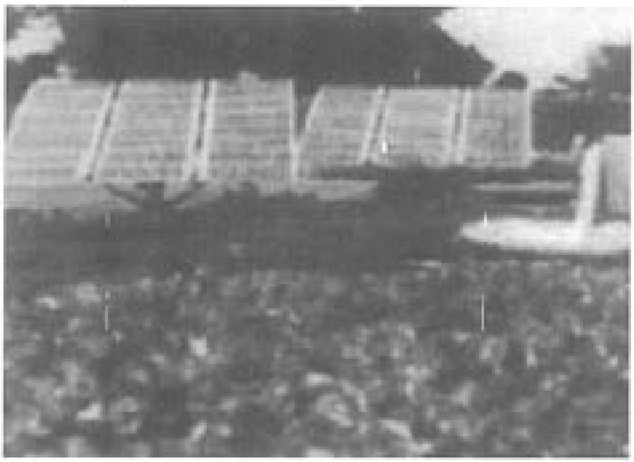

Fig. 9 : Solar water pump

2.8 Solar inverter

The solar inverter is available in three different capacities and requirements i.e. 600VA, 800VA and 1400VA. The system comprises one or two batteries charge controller/inverter and matching capacity solar panels. The system is capable of taking two to five rooms electrical load for 3 to 8 hours or so, depending upon load and power consumption situations. The system cost varies from 37,500/- to 1,25,000/- depending upon power load matching requirements. The solar inverter schematic is shown in Fig. 10.

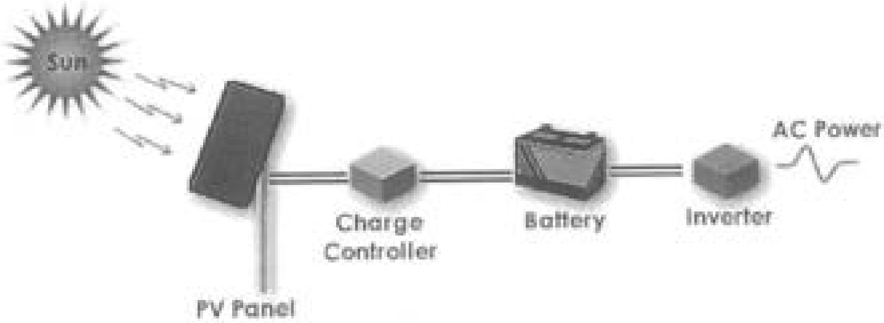

Fig. 10 : Solar power inverter

2.9 Solar electricity generation system

The system composing solar PV panels and charge controller/inverter convert the sun's rays into electricity that can be reliably used in homes or farms. In most systems, solar panels are placed on the roof, hence these systems are also popular by the name of roof-top solar system. An ideal site will have no shade on the panels, especially during the prime sunlight hours. The roof-top solar systems are available in different load ratings in the market broadly in three different segments; namely standalone system (with batteries), grid-tied system (with-out batteries) and hybrid system (batteries interactive with grid). The best among these in terms of economy and initial cost is grid-tied system. The grid-tied system is installed with net metering (bi-directional meter) provisions of state power corporation to off-set electrical load on the grid and provide electricity bill savings to the user, as shown in Fig. 11. The cost of grid-tied net metering system for 1 kW to 10 kW system is rupees 57,751/- per kW with provision of subsidy of rupees 17,325/- per kW. Under net metering policy, all consumers of electricity having minimum sanctioned load of 1.25kW and maximum of 12.50kW can install roof-top solar net metering system with capacity ranging from 1kW to 10kW i.e. 80% of sanctioned load.

3. Biomass Based Energy

Agricultural biomass is a domestic energy resource, and farmers have the chance to extend their function from a supplier of raw material to managers of domestic energy resources. Agricultural and forestry residues, energy crops, dairy-house, piggery, poultry, domestic and industrial waste based biomass will play a pivotal role in the replacing the fossil fuels with renewable resources. Biomass will contribute 83% to the increased use of renewable resources, [5]. Agricultural biomass is readily available and can be used to drive energy continuously. Rural or regional energy systems of the future will have to be based on renewable sources to a much larger extent [6].

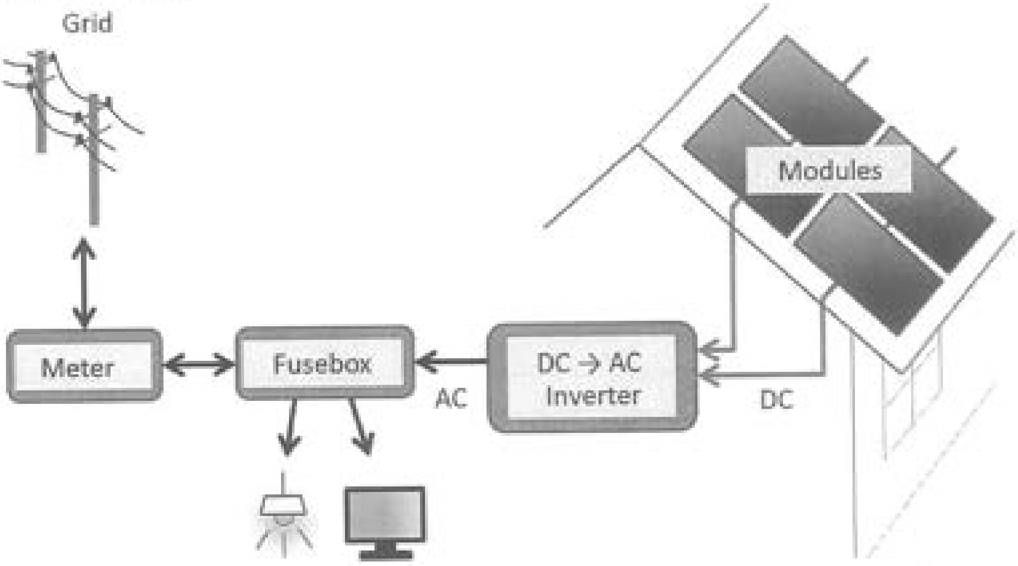

Fig. 11 : Grid-tied net metering solar electricity generation.

3.1 Biomass cook stoves

The National Biomass Cook-stoves Initiative (NBCI) was launched in India in late 2009 to extend the use of clean energy to all of India's households through the development of 'the next-generation of household cook-stoves, biomass-processing technologies, and deployment models' [8]. There were a number of solid biomass using stoves, which produce emissions per meal that are less than one-fifteenth that of traditional stoves in lab tests, with greater reductions seemingly possible [17]. The potential advantages of biomass based innovative technologies include: reduction in indoor air pollution, decreased per capita energy consumption and various other societal welfare benefits [4]. However, for improving health & indoor air quality, solving rural fuel-wood crisis, stopping deforestation, empowering women and addressing climate change, a new scheme of providing clean cooking fuel to every rural household (PMUY) was started in mid-2016 leading to closure of improved cook stoves policies [10].

3.2 Biomass gasifiers

The combustion products in gasifiers, mainly carbon dioxide, water vapour, nitrogen, carbon monoxide and hydrogen pass, in restricted air supply, through the glowing layer of charcoal for the reduction process to produce combustible 'producer' gas. During this stage both carbon dioxide and water vapour, oxidize the char to form CO, H_2 and CH_4. Gasifiers are broadly classified as per; i) the direction of gas flow and ii) the output or capacity of the gasifiers. The gasifier are also classified as per the type of fuel bed i.e. (i) Fixed bed and (ii) Fluizised bed [12]. An extensive review of gasifier manufacturers offering 'commercial' gasification plants from which: 75% of the designs were downdraft type, 20% of the designs were fluidized bed systems, 2.5% of the designs were updraft type, and, 2.5% were of various other designs, [7]. However, there was very little information on cost aspects, emissions, efficiencies, turn-down ratios and actual operating hours experience. Above all, no single manufacturer was ready to give full guarantee for technical performance of their gasification technology, [9].

3.3 Bio-gas plants

In a country like India, where about 68.8% of the total population lives in rural areas, [1], one such alternative is the use of biogas. Biogas, a product of anaerobic of cellulosic biomass, like cattle dung, poultry droppings, pig excreta, human excreta, crop residues etc., abundantly available in rural areas, is suitable fuel for providing heat and operating stationary engines. This combustible gas contains 50-60% methane, 30-40% carbon dioxide, 1-5% hydrogen and traces of nitrogen, hydrogen sulphide, oxygen, water vapours etc. [14]. It also enhances fertilizer value of the waste, provide a conventional, safe, aesthetical and economical waste disposal method. A biogas plant is a device for conversion of fermentable organic matter, in particular cattle dung, into combustible gas and fully matured manure. The design of a biogas plant is directly linked to its hydraulic retention time (HRT). The HRTs of biogas plants are different for different regions of India. For the majority of the regions in Indian, including Punjab, it is 40 days.

3.2.1 Design models of biogas plant: Biogas plants are mainly classified as; (i) batch type and continuous type, (ii) brick masonry dome and steel drum type. Biogas plants are classified as per use i.e. (i) Domestic level, (ii) Institutional level and (iii) Community level [11].

3.2.2 Selection of size of biogas plant: The size (capacity) of a biogas plant means the quantity of biogas (m^3), which we can get from it on a 24 hour basis. The selection of the size of biogas plant to be installed depends upon the number of persons to be served or the quantity of cow dung available. Per person, 0.34–0.42 m^3 of biogas is required for cooking food, and 1 kg of cattle dung has a potential of producing about 0.04 m^3 of gas. Hence, once the process is set in, 25 kg of dung is required per 1 m^3 of biogas production. Normally, 10–20 kg of dung is collected from ordinary cattle, [14]. The calculations, hence made, are shown in Table 4.

Table 4 : Number of persons served, requirement of dung and number of animals for different sizes of biogas plants.

Sr. No.	Capacity of biogas plant (m^3)	No. of animals required	Quantity of dung required (kg)	Cooking for number of persons
1	2	3-4	50	4-5
2	3	5-6	75	7-8
3	4	7-8	100	10-11
4	6	10-12	150	4-16

3.2.3 Cost of installation of biogas plants: The cost of installation of different family size biogas plants that includes material and labour cost, as per criteria adopted by Singh K J and Sooch S S, [14], at the prevalent market rates is given in Table 5.

Table 5: Installation costs of different types of biogas plants.

Sr. No.	Biogas plant models	Plant Capacity			
		2 m^3	3 m^3	4 m^3	6 m^3
1.	KVIC type	30,000/-	37,000/-	43,000/-	55,000/-
2	Janta type	26,000/-	30,000/-	32,000/-	40,000/-
3	Deenbandhu type	20,000/-	25,000/-	30,000/-	35,000/-

The Government of India, for promoting the use of biogas, is providing a fixed amount of financial assistance in rupees, as given in Table 6, [2].

Table 6 : Central Financial Assistance under the New National Biogas and Organic Manure Programme, w.e.f. 01.04.2018, in `000 `.

Sr. No.	Financial Assistance for different regions of India	Capacity of family type biogas plants, m3/day					Contacting Agency
		1	2 to 6	8 to 10	15	20 to 25	
1	NER States, including Sikkim and including SC/ST categories of NER	17	22	24	25	35	District level or Nodal officers of State level Energy Development Agency
2	Special category states (Jammu & Kashmir, Himachal Pradesh, Uttrakhand, Andaman & Nicobar Islands and including SC/ST categories of all other states	10	13	18	21	28	
3	All others states (general category)	7.5	12	16	20	25	
6	Additional for toilet linked Biogas Plants	1.6	1.6	1.6	--	--	

Punjab is all set for leading change in renewable energy sector due to a large scale investment in solar power projects, net metering policy and farm-level solar power projects. Punjab was rated as the number one State in India for progress in solar energy by World Bank. The state aims to accomplish the goal of generation of 15% power requirement through renewable energy by 2022 [13].

4. Conclusions

There is huge potential in converting incident solar energy into useful energy either through thermal route or through photovoltaic route but the cost factor is keeping the general users at distance. Among other renewable energy conversion systems, thermal gasification, has great potential because of its flexibility to use a wide range of feedstock, and to produce energy vis-à-vis wide range of fuels and chemicals. Abundant quantities of crop/forestry based biomass is available, it can be optimally used for thermal and power requirements of villages by empowering village co-operatives with technical know-how of the technology along with convincing incentives that may change the overall energy scenario at rural level.

Biogas plants are successful in outer peripheries of villages or in fields. Apart from cooking or lighting the house, it can also be used to power combustion engines to drive a mechanical motor or generate electricity. Biogas has two types of economic benefits one is it saves the energy cost to be purchased and on the other hand extra money can be earned by selling biogas in the locality. Biogas units are less successful in the interiors of villages, due to difficulties in arranging for land, water and feedstock required for the plants.

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Impact of PKV Mini Dal Mill on Its Owners

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Abstract: The study entitled "Impact of PKV Mini Dal Mill on its owners was purposively implemented in Akola and Amravati districts of Vidarbha region. For this study, a list of owners of PKV Mini Dal Mill who had started their plant since 2015-2016 was collected from the Department of Post Harvest Engineering and Technology, College of Agricultural Engineering and Technology, Dr.P.D.K.V.Akola. A sample of ten owners of PKV Mini Dal Mill was purposively drawn from Akola and Amravati districts.

The findings revealed that, majority of PKV Mini Dal Mill owners were from middle age group, had education up to secondary school, possessed semi-medium land holding, agriculture as main occupation, with medium level of farming experience.

Regarding the impact of PKV Mini Dal Mill on its owners was studied in terms of change in annual income, change in social participation, change in material possession and change in employment generation. It was found that, there were change in annual income, social participation, material possession and employment generation in PKV Mini Dal Mill owners after adoption of PKV Mini Dal Mill owners over before adoption of PKV Mini Dal Mill owners. There were total change was found to be 48.29 per cent. While going through results of this study, it was found that 80.00 per cent of the respondents have high level of change in their annual income after adoption of PKV Mini Dal Mill. It was also found that 60.00 per cent respondents have medium level of change in their social participation after adoption of PKV Mini Dal Mill. It was also revealed that 90.00 per cent respondents have high level of change in their material possession after adoption of PKV Mini Dal Mill whereas 70.00 per cent respondents have high level of change in their employment generation after adoption of PKV Mini Dal Mill.

The results of this studies pointed out that the owners were satisfied with PKV Mini Dal Mill as it is the source of continuous income generation. It is also observed that most of the people have knowledge about PKV Mini Dal Mill but there were less adoption of PKV Mini Dal Mill. Most of the respondents were unaware about government subsidies on PKV Mini Dal Mill. PKV Mini Dal Mill is a good subsidiary occupation rather than faming but very few peoples were taking advantage of this. For improving this situation it is necessary that there should be combined efforts of Post Harvest Technology and Engineering Department, extension agencies, KVK's to create awareness and interest about PKV Mini Dal Mill. Provision of loans, various policies, schemes and government subsidies should be given.

Introduction

India is the largest producer (25.00% of global production), consumer (27.00% of world's consumption) and importer (14.00%) of pulses in the world. Pulses account around 20.00 per cent of area under food grains and contribute around 7.00-10.00 per cent of total food grain production in the country. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Karnataka are the top five pulses producing states. Productivity of pulses is 764 kg/ha. (www.icrisat.org).

As the production of pulses in Vidarbha region of Maharashtra state is increasing day by day, the Akola and Amravati districts of Vidarbha region are important according to pulse processing point of view. Keeping this in point of view of small farmers, PKV Mini Dal Mill, which is a compact mini dal mill with all essential operations, has been developed at Dr.PDKV, Akola. It uses an electric motor of 3.0 hp. It is advantageous to small scale processors due to less cost and space economy and also the investment is low with higher dal recovery as compared to commercial dal mills at rural levels. Similarly, it can save the transportation and handling losses to the extent of 3.7 per cent. With the use of this PKV Mini Dal Mill, it is possible to process the pulses at home, which can work for 150-250 days per annum with 72-75 per cent dal recovery for red gram, 80-82 per cent dal recovery for green gram and black gram. Its processing capacity is 10 qt. for red gram and 12 qt for green gram and black gram per day. This mill can also give 3-4 per cent more dal recovery than the mega dal mills. Such processing is possible through the use of "PKV Mini Dal Mill Plant.

Methodology

The study entitled "Impact of PKV Mini Dal Mill on its owners: A Case Study" was purposively implemented in Akola and Amravati districts of Vidarbha region. For this study, a list of owners of PKV Mini Dal Mill who had started their plant since 2015-2016 was collected from the Department of Post Harvest Engineering and Technology, College of Agricultural Engineering and Technology, Dr.P.D.K.V. Akola. A sample of ten owners of PKV Mini Dal Mill was purposively drawn from Akola and Amravati districts.

The data was collected from 10 PKV Mini Dal Mill owners with the help of structured and pretested interview schedule. A case study method of social research was used for present investigation.

The specific objective of the study is as under

1. To study the impact of PKV Mini Dal Mill on its owners

Results And Discussion

Distribution of PKV Mini Dal Mill owners according to impact parameters

1) Change in annual income

It is operationally defined as the total earnings in rupees of the PKV Mini Dal Mill owner and his/her family members derived from all sources during a year.

The per cent change in annual income was worked on the basis of differences in annual income before and after the adoption of PKV Mini Dal Mill.

Distribution of the PKV Mini Dal Mill owners according to their annual income have been furnished in Table 1.

Table 1 : Distribution of the PKV Mini Dal Mill owners according to their annual income

Sl. No.	Annual Income	Before adoption of PKV Mini Dal Mill		After adoption of PKV Mini Dal Mill	
		Frequency	Per cent	Frequency	Per cent
1.	Up to 60,000/-	02	20.00	00	00.00
2.	60,001/- to 1,20,000/-	07	70.00	02	20.00
3.	Above 1,20,000/-	01	10.00	08	80.00
	Total	**10**	**100**	**10**	**100**

It is evident from Table 1 that, only (20%) of PKV Mini Dal Mill owners had annual income up to Rs. 60,000/- before adopting PKV Mini Dal Mill enterprise, followed by 70.00 per cent PKV Mini Dal Mill owners had annual income above Rs. 1,20,000/- rupees and only 10.00 per cent had annual income in between Rs. 60,001/- to Rs. 1,20,000/- before adopting PKV Mini Dal Mill enterprise.

In case of after adoption of PKV Mini Dal Mill enterprise, (00%) of PKV Mini Dal Mill owners had annual income up to Rs. 60,000/-, followed by 20.00 per cent had annual income in between Rs. 60,001/- to Rs. 1,20,000/- and majority 80.00 per cent of the PKV Mini Dal Mill owners had income above 1,20,000/-.

2) Change in social participation

It refers to the extent of participation of PKV Mini Dal Mill owner in various formal and informal organizations as member or office bearer of that organization.

The per cent change in social participation was worked on the basis of differences in before and after the adoption of PKV Mini Dal Mill.

Distribution of the PKV Mini Dal Mill owners according to their social participation have been furnished in Table 2.

Table 2 : Distribution of the PKV Mini Dal Mill owners according to their social participation

Sl. No.	Social Participation	Before adoption of PKV Mini Dal Mill		After adoption of PKV Mini Dal Mill	
		Frequency	Per cent	Frequency	Per cent
1.	Low	04	40.00	01	10.00
2.	Medium	05	50.00	06	60.00
3.	High	01	10.00	03	30.00
	Total	**10**	**100**	**10**	**100**

It is evident from Table 2 that 50.00 per cent of PKV Mini Dal Mill owners had medium level of social participation followed by 40.00 per cent had low level of social participation and 10.00 per cent had high level of social participation before adoption of PKV Mini Dal Mill enterprise.

In case of after adoption of PKV Mini Dal Mill enterprise, majority (60%) of PKV Mini Dal Mill owners had medium level of social participation, followed by 30.00 per cent had high level of social participation and 10.00 per cent had low level of social participation.

Thus, it is concluded that majority of PKV Mini Dal Mill owners had medium level of social participation.

3) Change in Material possession

It is operationally defined as the possession of various household materials by the PKV Mini Dal Mill owner. The per cent change in material possession was worked on the basis of differences in material possession before and after the adoption of PKV Mini Dal Mill.

Distribution of the PKV Mini Dal Mill owners according to their material possession have been furnished in Table 3.

Table 3 : Distribution of the PKV Mini Dal Mill owners according to their material possession

Sl. No.	Material possession	Before adoption of PKV Mini Dal Mill		After adoption of PKV Mini Dal Mill	
		Frequency	Per cent	Frequency	Per cent
1.	Low	00	00.00	00	00.00
2.	Medium	06	60.00	01	10.00
3.	High	04	40.00	09	90.00
	Total	**10**	**100**	**10**	**100**

It is evident from Table 3 that 60.00 per cent of PKV Mini Dal Mill owners had medium level of social material possession followed by 40.00 per cent had high level of social material possession and 00.00 per cent had low level of material possession before adoption of PKV Mini Dal Mill enterprise.

In case of after adoption of PKV Mini Dal Mill enterprise, majority (90%) of PKV Mini Dal Mill owners had high level of material possession, followed by 10.00 per cent had medium level of material possession and 00.00 per cent had low level of material possession.

Thus, it is concluded that majority of PKV Mini Dal Mill owners had high level of material possession after adoption of PKV Mini Dal Mill enterprise.

4) Change in Employment generation

Employment generation is natural process of social development. It refers to the employment generated through PKV Mini Dal Mill plant.

The per cent change in employment generation was worked on the basis of differences in employment generation before and after the adoption of PKV Mini Dal Mill.

Distribution of the PKV Mini Dal Mill owners according to employment generation have been furnished in Table 4.

Table 4 : Distribution of the PKV Mini Dal Mill owners according to employment generation

Sl. No.	Employment generation	Before adoption of PKV Mini Dal Mill		After adoption of PKV Mini Dal Mill	
		Frequency	Per cent	Frequency	Per cent
1.	Low	00	00.00	00	00.00
2.	Medium	00	00.00	03	30.00
3.	High	00	00.00	07	70.00
	Total	**00**	**00**	**10**	**100**

It is evident from Table 4 that in case of after adoption of PKV Mini Dal Mill enterprise, majority (70%) of PKV Mini Dal Mill owners had high level of employment generation, followed by 30.00 per cent had medium level of employment generation and 00.00 per cent had low level of employment generation.

Thus, it is concluded that majority of PKV Mini Dal Mill owners had high level of employment generation after adoption of PKV Mini Dal Mill enterprise.

Impact of PKV Mini Dal Mill owners on its owners

The impact score of PKV Mini Dal Mill will be computed by summing up the values of mean of change in percentage with regard to the four impact parameters i.e change in annual income, change in social participation, change in material possession, change in employment generation. Mean score of all the dimensions of impact, their per cent change are furnished in table 5.

Table 5 : Impact of PKV Mini Dal Mill on its owners

Sl. No.	Impact Dimension	Mean score		Per cent change
		Before adoption of PKV Mini Dal Mill	After adoption of PKV Mini Dal Mill	
1.	Change in annual income	124975	212798	35.75
2.	Change in social participation	8.52	11.89	31.29
3.	Change in material possession	42.65	66.25	28.16
4.	Change in employment generation	00.00	74.00	34.55
	Mean			**48.29**

A cursory look at Table 5, revealed that mean score of owners after starting PKV Mini Dal Mill enterprise for change in annual income (212798), change in social participation (11.89), change in material possession (66.25) and change in employment generation (74.00) were higher than the mean score of before starting PKV Dal mill for change in annual income (212792), change in social participation (8.52), change in material possession (42.65) and change in employment generation (00), respectively.

Summary and Conclusion

It was also found that there was change in annual income, social participation, material possession and employment generation to the tune of 35.75, 31.29, 28.16and 34.55 per cent over that before starting the PKV Mini Dal Mill owners. Because of the starting the PKV Mini Dal Millenterprise, it resulted change inannual income, social participation, material possession and employment generation.

When impact as whole was considered it is seen that there was overall impact of 48.29 per cent of starting PKV Mini Dal Mill enterprise on its owners. It could therefore there was definite positive impact of starting PKV Mini Dal Mill enterprise on its owners in terms of change in annual income, social participation, material possession and employment generation to the extent of 48.29 per cent over and above as a whole.

Thus because of the starting the PKV Mini Dal Mill enterprise, it resulted change in annual income, social participation, material possession and employment generation. There was overall impact of 48.29 per cent of starting PKV Mini Dal Mill enterprise on its owners. It could stated that there was definite positive impact of starting PKV Mini Dal Mill enterprise on its owners in terms of change inannual income, social participation, material possession and employment generation, it could definitely be inferred that, the starting PKV Mini Dal Mill enterprise had a positive and significant impact on the owners.

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Food Processing Technology : Bonanza for Young Entrepreneurs

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Abstract: Entrepreneurship development in agriculture is an approach of developing human resource and train the youth for taking risk and managing resources in efficient way. Food processing industry provides the vital linkage between industry and agriculture and is of enormous significance for India's development. The prospects for increasing processing levels are more as India is moving from a position of scarcity to surplus in food production. The need of the hour is to move up the value chain in processed food products by establishing efficient backward linkages to contribute to nation's food security as well as contribute towards improving the income level of the farmers by reducing food wastages and enhance food as well as processed food exports. Though India is a large sourcing hub for agricultural produce, it has the advantage of a large and growing market. Now a day the size of processed food market is increased because of changing consumption patterns due to urbanization, changes in the gender composition of work force, and growing consumption rates. Further, more than two thirds of our 1.3 billion populations are young with growing incomes also create a large market for food products. All these factors lead to growing consumption of food which is expected to reach US $ 1.2 trillion by 2025-26. Entrepreneurship need more focus and emphasize for tapping all such cashing opportunities. Food processing plays a vital role in multiformity and commercialization of agriculture, enhances shelf life of agricultural produce, ensures value addition to agro products, generates employment, enhances income of the farmer and creates market for export of agricultural food products. This paper aims at different innovations in agribusiness for young entrepreneurs.

Keywords: *food, entrepreneur, innovation, technology.*

I. Introduction

Poverty and unemployment are the two main challenges in India. Increase in productivity is not only way to develop rural economy, it requires subsidiary activity such as rural industry and food processing industry. Food processing Industry can provide an employment opportunity to the people of rural areas and creates linkage between agriculture and industry. Also it will modify the economic well-being by increasing their income and there will be reduction in migration of rural people to cities which results in increases slums. This provides ample opportunities to the modern minded farmers and entrepreneurs to line up an agro business and food process business. Food processing industry links two pillar of an economy (agriculture and industry) and plays a very significant role for the development of India. As India is moving from a position of scarcity to surplus in food production there is likelihood for huge increase in level of food processing. Entrepreneurship helps to come out from economic crisis and hence is one of the key drivers for economic development. Entrepreneurship has been linked to improved growth, increased wealth and quality of life. Improvement in growth, increased wealth and quality of life are the outputs of Entrepreneurship. Because of over-dependence on agriculture for employment in India, planning and implementation for development of entrepreneurial programmes are essential for raising the living standard of the majority of the backward regions (Uplaonkar and Biradar 2015). Thus, entrepreneurship development appears to be the best substitute to find employment opportunities, income generation, poverty reduction and improvements in nutrition, health and overall food security in the national economy. The term agri-entrepreneurship is similar with entrepreneurship in agriculture and describes agribusiness establishment in agriculture and allied sector (Bairwa et al., 2014). Entrepreneurship in agriculture can also be defined as the formation of novel economic organization for the intention of growth under risk and uncertainty in agriculture (Dollinger, 2003). Contrary, Gray (2002) defines an entrepreneur as an individual who controls a business with the purpose of growing the business along with leadership and managerial skills necessary for achieving those goals. The objective of the paper is to overview the trends and opportunities for youth in food processing sector, challenges and drivers for rural development, Income Generation with Inclusive Growth in food processing sector.

II. Present Scenario in Agriculture

India rank seventh next to Russian Federation, Canada, USA, China, Brazil, Australia and share 2.44% of total area. India rank first in rural population (889.22 million) and share 26.08% in world. India ranks 3rd and produces 313.61 MT (million tons) of total cereals, 23.24 MT of pulses and ranks first, 9.18 MT groundnut (with shell) and ranks second, 7.92 MT of rapeseed and rank 3rd in world. In commercial crops we stands first in jute production, second in sugarcane and cotton and eight in coffee (green). India ranks second position in production of fruits and vegetables with 127.14 MT of vegetables, 92.30 MT of fruits, 48.61 MT of potatoes and 22.43 MT of onion (dry). We rank 1st in milk production, 3rd in Egg and 6th in meat with production of 176.27, 4.85, 7.30 MT respectively (Agricultural Statistics 2019). Year wise production of cereals, pulses and oilseeds in Maharashtra is given in Figure 1 (Anonymous 2019a)

Fig. 1 : Year wise production of cereals, pulses and oilseeds in Maharashtra

III. Need of Agro Processing

India ranks first in production of Banana (25.7% of world production), Papayas (43.6% of world production), and Mangoes (40.4% of world production) (Horticultural - Statistical Year Book India 2018). Horticultural produce in India have unique aroma, flavour, taste, nutritional properties and health benefits such as Jamun, Amla, Bel fruit, pomegranate, custard apple etc. In spite of this record production our farmers remains poor with less income. This is because farm gate prices of agricultural commodities are very low compared to the price of processed and packaged product consumer pays. Hence GDP from agriculture is only 15% (GVA 17.76%) (MoSPI, 2020), though it employs 49% work force and sustains 54.6% population (Deshpande, 2017). Though India ranks second in the world in agricultural production, we incur very heavy losses in this produce. However it is saddening that annual post harvest loss in food grains is 10% and in fruits and vegetables it is 20% which comes to about 1 lakh crore per year (Khan, 2020). These heavy losses are due to improper post harvest handling and very low level of food processing in production catchment. Handling of raw produce through many stages of middlemen, Low level of processing mostly in urban areas which leads to wastage of valuable by-products, Non availability of sufficient cold chain facilities, Non availability of adequate equipment and machinery for small scale processing and Lack of facilities for training, incubation and handholding of entrepreneurs are the main reasons for post harvest loss. It is very simple to understand that perishable produce of agriculture needs to be processed as early as possible and as you delay in it's processing in urban areas. The processing of any agriculture produce yields substantial quantity of valuable by product along with main product.

IV. Food Processing Sector Overview

At present India process overall less than 10% of its agricultural produce which includes processing of fruits and vegetable (2%), poultry (6%), meat (21%), marine (23%) and milk (35%). mostly primary processing is done through rice, sugar, edible oil and flour mills etc in India (MoFPI, 2019). Secondary processing offers high value-addition than primary processing. Secondary processing includes processing of high value items viz fruits and vegetables, dairy, bakery, chocolates etc. Farmer income level can be improved by reducing food wastage which are as high as US$1.5 billion- Rs 92,000 crores annually simultaneously moving up the value chain in processed food products by constructing well organized backward linkages to contribute to nation's food security (MoFPI Estimate, 2019) and enhance export of food as well as processed food which currently stand at 2.31% and 10.69% respectively (MoFPI annual report 2018-19). Food processing has set growth of 10.35% from 2010-11 to 2016-17 and provides large employment (MoFPI annual report 2018-19).

V. Growth rate and Investments

As per the latest Annual Survey of Industries (2016-17) data, food processing accounted factories (15.95%) and employed workforce (11.36%) and output of 14.09%. Changing consumption patterns due to urbanization, changes in the gender composition of work force, and growing consumption rates have contributed to the increase in the size of processed food market. With these forces in play, going forward the India market size for food is expected to reach USD 544 billion by 2020-21 (CII estimates) whereas the food industry output is expected to reach US $ 535 billion in 2025-26 (CII estimates). Further, more than two thirds of our 1.3 billion populations are young with growing incomes also create a large market for food products. All these factors lead to growing consumption of food which is expected to reach US $ 1.2 trillion by 2025-26(CII estimates).

VI. Key Sub-Segments

The significant production strength along with low levels of current processing offer huge opportunities for growth of the food processing industry in India. India is the second largest producer of the F & V (Fruits and Vegetables) in the world; however, the processing levels in F&V currently stand at a low of 2%. Thus, there is a huge opportunity in harnessing the potential of processed fruits and vegetables in the form of frozen (IQF), canned, pulp, puree, paste, sauces, snacks, dressings, flakes, dices, dehydrated products, pickles of different fruits and vegetables, juices of fruits and vegetables, slices of different exotic fruits, chips like potato, banana etc; fruit jams, jelly, etc. The dairy segment in India is comparatively advanced with a 35% processing level at present. However, the scope is still significant. Per capita accessibility of milk in India has reached 375 grams per day in 2017-18, that is over the globe average of around 294.2 grams per day in 2017. Thus, the opportunities for value added products such as ghee, flavored yogurt; butter (with variants), flavored milk, cheese etc. are abundant.

VII. Budding Food Regulatory Ecosystem

A) Food Grain: India is witnessing wastage within the range of 4.65% – 5.99% (APEDA, 2019) in cereals majorly because of lack of storage infrastructure and primitive grain handling mechanism. To scale back this wastage level and fulfill the increasing demand for grains and its processed forms, India desires adequate infrastructure, process facility and research & development in this sector.

- Processing of cereals to high value products like snacks, ready to cook/ready to eat products, bakery products etc.
- Share of healthy variants of cereals based products such as multi-grain flour, brown bread, brown rice, multigrain bread; whole wheat bread etc. is witnessing significant growth.
- Super cereals or millets are witnessing a huge demand domestically and in global markets due to the health benefits that they offer. Opportunity for millet-based value added products.

B) Fruits and Vegetables: India witnesses nearly 4.58 – 15.88% (Jha, et. al., 2015) wastage in fruits and vegetables annually, due to lack of modern harvesting practices and inadequate cold chain infrastructure. Further the processing levels in F&V currently stand at a low of 2%. Opportunity therefore lies in investing in initiatives that help reduce wastage levels including adequate infrastructure (cold chain, processing infrastructure), R&D for processed food & packaging, innovative on farm preservation systems and skill development. There is a huge opportunity in harnessing the export potential of processed fruits and vegetables in the form of frozen (IQF), canned, pulp, puree, paste, sauce, snacks, dressings, flakes, dices, dehydration, pickles, juices, slices, chips, jams, jelly, RTS drinks etc.

C) Dairy: Despite its inspiring performance, the sector faces several issues throughout the value chain. The segregated structure of the sector and marginality of the majority of farmers, and limited impact of technological innovations have resulted in several significant issues that are plaguing the sector. Given the fragmentation and small volume of milk handled by individual farmers, milk procurement itself becomes challenging. The breeding related issues and unavailability of high yield pure breeds, lack of expert knowledge about feeding and healthcare of the cattle, drugs and antibiotic related unawareness, absence of technological means to predict optimum production cycle of the animal are some of the key areas that need immediate intervention. Indicative chance in dairy Sector is innovation in packaging solutions advanced technology equipment for increasing milk procurement efficiency, value addition for dairy product, etc. Opportunity lies in new product development for cows feed and value-added dairy product viz. cheese, smoothies, flavoured milk, custard, yogurt and different ethnic Indian product (MOFPI Investor Portal, 2020).

VIII. Growth Trends in Budding Processing Sub Segments

The India market size for food is expected to reach USD 544 billion by 2020-21(CII estimates 2019) whereas the food industry output is expected to reach US $ 535 billion in 2025-26(CII estimates 2019). Within the Indian food and beverage industry, there are certain segments that are gaining increasing acceptability and thereby creating immense opportunities for increasing domestic consumption as well as exports. Fig 2 shows sales volume of processed product.

i) Packaged food segment: The growth in the segment is also supported by shift in consumer preference for branded packaged products, amid rising awareness of healthy living. The growth is further fuelled by increasing competition in the segment with new product launches and new entrants leading to increased choices for consumers and the strong growth is expected to continue till 2023. Demand towards branded packaged food is also driving the convenience seeking urban consumers to shop online or in hypermarkets and supermarkets.

ii) Breakfast cereals: The breakfast cereals segment is becoming more competitive with new entrants as well as innovative variants targeting the health conscious consumers. The segment is getting re-positioned as a healthy snack segment with introduction of variants such as muesli and granola. The entry of new variants has impacted the traditional breakfast cereal product, flakes, market for which has registered a decline in retail value growth during 2018.

iii) Bakery products: With introduction of GST price packaged flat bread (Chapattis, naans, roti, paratha, kulcha) moved to a lower tax bracket of 5% resulting in rise of sale. Additionally, packaged flat bread responded to the consumer need for availability of single and multi-serve pack sizes which further supported sales. The dessert mixes sub-segment is evolving from conventional mixes to more global dessert mixes recipe viz cakes, pastries, ice creams, biscuits etc. The bakery segment is further evolving with introduction of premium variants such as croissants, filled muffins, cookie cakes, sweet puffs etc in packaged formats. *iv) Processed fruits and vegetables:* Given year-round supply of fresh fruits and vegetables, frozen vegetables sales are declining in retail outlets, but picking up among foodservice players. Consumers are becoming more exposed to International snacks however frozen potato products remain the popular snack option. While the processed fruits and vegetables have some established organized players, the segment is witnessing new entrants which are growing fast.

v) Processed Meat and Seafood: Owing to policy barriers on slaughtering and selling beef fresh and processed formats sales were impacted in 2018. However, the frozen processed sea food segment gained popularity and witnessed increase in demand for international sea food. Growth in the seafood segment is also fuelled by internet retailing channels, increasing focus on nutritious food, and the convenience of long term storage. Encouraged by the benefit in terms of increased shelf life of meat, independent small grocery retailers are also setting up compact freezers and chillers thus strengthening the backend.

vi) Pasta and Noodles: Overall noodles sales recovered completely during 2018 after a major setback in 2015 Pasta dishes have become a common meal option for Indian consumers with Italian and Mediterranean cuisines gaining popularity.

vii) Edible oils: Consumer shift towards olive oil and rapeseed oil as preferred edible oil was witnessed in 2018; however olive oil given its high prices continued to face a considerable challenge from blended oils products. In the lower income segment Palm oil continued to find a huge consumer base given the lower prices in 2018.

viii) Ready meals: Ready to eat meal is still a small category in India partly due to a strong preference for fresh food among Indian consumers however with increasing working population seeking convenience the segment offers growth potential. To capture the market, manufacturers are offering a range of options to suit the consumer palate, encompassing everything from traditional Indian meals to exotic dishes. Within the ready meals segment frozen ready meals remained the largest category in value terms in 2018 and posted the fastest growth in current value sales.

ix) Sauces, Dressings and Condiments: During 2018 dry sauces were the largest category within sauces, dressings and condiments in India in value terms and continued to post strong double-digit growth in current value sales. Mayonnaise and salad dressings also recorded strong growth in current value sales in 2018 given the growing exposure to western cuisine via food service outlets.

x) Soup: Growth in Soup consumption supported current value sales in 2018, though this category remained relatively small as compared to other countries such as China and Japan. While tomato remained the most popular flavour within soup in India in 2018, the category is witnessing an influx of new flavours, including classic international options. Dehydrated soup remained the dominant soup category in India in value terms in 2018, given convenience, ease of preparation as well as perception of a healthier option.

xi) Chocolate confectionary: While demand for premium chocolates saw an increase, but availability was limited. Flavour innovation is a new trend driving chocolate confectionery with manufacturers experimenting with new flavours such as coffee, cinnamon etc in addition to fruit flavours such as strawberry and orange peel. There is positive buzz around dark chocolate, which has lower sugar content also favoured rising demand in the sector.

xii) Dairy: Increasing consumption of burgers, pizza and pasta, is driving growth within the dairy farm section with cheese being a key ingredient in such dishes. Inside the cheese class variants like mozzarella, cheddar cheese and parmesan, are gaining popularity. In 2018, unprocessed cheese in India continuing to be dominated by paneer and unorganised channel remained the most important provider. Among the drinking milk product, flavoured milk is continuing to trounce alternative variants. Also, premium milk with longer shelf life, is gaining popularity.

xiii) Beverages: Naturally healthy beverages continued to witness significant value growth in 2018 with demand for natural ingredients and flavours such as orange, mango and apple remaining the most popular. Ayurveda-based juices, such as aloe vera and amla, and vegetable juices are also witnessing greater demand in India. Organic beverages segment is also evolving with Organic tea capturing the largest share. In the fortified/functional beverage segment, sports drinks continued to see a strong value sales performance in 2018.

IX. Various Trends Shaping the Future of the Sector

The opportunity lies in combining taste and health benefits while making it convenient for prospective customers. The increasingly thoughtful and mindful consumer are changing the way that companies produce, package and label their products and detailed, honest and accurate labeling is emerging as a key product differentiation strategy. As India continues to increase its footprint as a key sourcing area across sectors, it is strategically positioned to take a leading role in promoting sustainable trade across value chains. There is an increased awareness on sustainability risks as well as opportunities amongst the businesses today and they are viewing responsible sourcing from India as a step towards brand building and creating supply chain leadership. The rewards are not only great; but these businesses stand every chance of growing as more companies accept the sustainability norm. With the sector becoming more focused in reducing its carbon and water foot print climate smart solutions are increasingly in demand and leading to innovations. With packaging emerging as the most direct and relevant form of reaching new levels of product differentiation and impacting buying behavior the un-organized sector presents huge opportunity. Packaging and branding are also emerging as a purchase influencer and communicator giving consumers alternatives to compare the value offerings before making a purchase. Food processing is one sector that cannot flourish without technology and automation. Globally, the food processing & handling equipment market is projected to reach USD 196.6 billion by 2025, at a CAGR of 6.2% from 2019 (Anonymous 2019b). Further automation will not replace people but will improve the skills workers need to keep up with the pace of change.

X. Policy Ecosystem

The Government of India has accorded 'high priority' status to the food processing industry. The Ministry of Food Processing Industries (MOFPI) has been set up as a nodal agency for formulation and implementation of the policies and plans for the food processing industries. Ministry of Food processing Industries (MoFPI), in partnership with the State/ UT Governments, has launched an all India Centrally Sponsored PM formalisation of micro food processing Enterprises theme (PM FME Scheme) for providing financial, technical and business support for up gradation of existing micro food processing enterprises (MOFPI, 2020). Under this scheme Individual micro food processing units desirous of up gradation of their unit can avail credit-linked capital subsidy @35% of the eligible project cost with a maximum ceiling of Rs.10 lakh per unit.

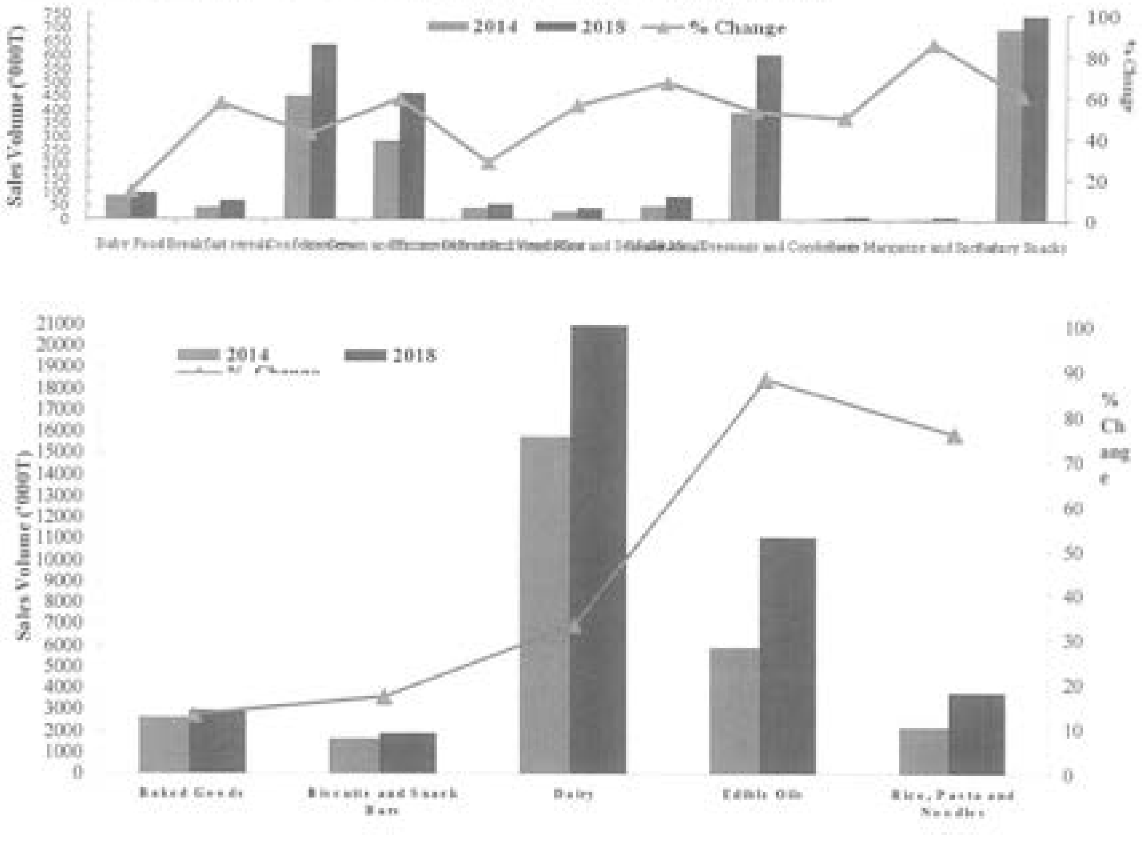

Fig 2 : India: Sales Volume of Packaged Foods in 2014 and 2018 ('000 Tons)

The beneciary contribution should be minimum 10% and the balance should be loan from a Bank. This scheme provides support to FPOs/ SHGs/ Producer Cooperatives for capital investment along the entire value chain with credit linked grant @ 35%. This scheme conjointly provides seed capital @ Rs. 40,000/- per SHG member would be provided to those engaged in food processing for working capital and get of small tools. Seed capital as grant would be provided to the SHG federation that, in turn, would be extended to members as loan through the SHGs (MOFPI 3 fold brochure, 2020). The electronic National Agriculture Market (e-NAM) portal was launched in 2016 with the vision of a single agriculture market. With a view to augment private investment to food processing sector, an umbrella scheme Pradhan Mantri Kisan SAMPADA Yojan (Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters) has been launched with an allocation of Rs. 6,000 crores for the period 2016-20. The PM Kisan SAMPADA Yojana is expected to leverage investment of Rs. 31,400 crores for handling of 334 lakh MT Agro-produce valued at Rs. 1,04,125 crores, benefiting 20 lakh farmers and generating 5,30,500 direct/indirect employment in the country by the year 2019-20. The Ministry of Food Processing Industries is implementing Mega Food Park Scheme with the aim of creating modern infrastructure facilities for food processing along the value chain from farm to market with strong forward and backward linkages through a cluster based approach. As per the scheme, monetary help of upto Rs. 50.00 crore per Mega Food Park project is approved. As per the newest revision within the GST rates, of the all food classes taken along underneath totally different chapter heads/subheads, 12 months of the food items are exempted from GST (0%) and thirty seven percent of the food items shall attract GST of five percent. Hence, nearly seventy three percent of the food items are underneath lowest tax block of zero percent or five percent. These items constitute bulk of material that goes into further value addition. Hence cost of production of processed item is predicted to fall. fixing and operating a cold chain facility; and fixing and operating warehousing facility for storage of agricultural produce: Deduction to the extent of 150% is allowed for expenditure incurred on investment Under Section 35-AD of the tax Act 1961. To boost easy accessibility of finance infrastructure status is provided for projects like Mega Food Parks and Cold Chain. A special fund of Rs.2000 crore has been discovered in national bank for Agriculture and Rural Development (NABARD) to supply credit at reasonable rates to spice up food processing sector (Annual Report MOFPI, 2019). Beneath this fund, loan is extended to individual entrepreneurs, cooperatives, farmers' producer organizations, corporate, joint ventures, SPVs and entities promoted by the govt. for fixing, modernization, and growth of food processing units and development of infrastructure in selected food parks. The loans are extended up to ninety five percent of the eligible project cost for entities promoted by the State Governments whereas different categories of promoters are extended loans up to seventy five percent of the project cost (MOFPI Outcome Budget 2017).

Conclusion

It can be seen that several processing technologies for several crop produce are available in our country which can be explored for commercialization and entrepreneurship development. The incentives by government through PM-FME, one district one product scheme can work as catalyst in increasing the level of processing, reducing post harvest losses and ultimately increasing farmer's income. In addition to already developed technologies, the ideas of the innovators to create solution to already existing problems in food processing can also be converted into reality through Agri-Business Incubation Centres located in Agri Universities and ICAR Institutes.

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Effect of Shelling Methods on Quality of Fresh Sweet Corn during Storage

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Abstract: Corn (*Zea mays L.*) is the most important cereal next to wheat and rice. It is also widely distributed throughout the world. Sweet corn has multiple uses but it is mainly grown for human and livestock consumption. The kernels of sweet corn are 25 – 30% much sweeter than normal corn. Fresh sweet corn is perishable due to its high moisture content and kernels losses tenderness and sweetness after shelling and during storage. Organoleptic acceptability, textural and other parameters plays an important role in the assessment of shelf life of sweet corn kernels during storage. Therefore, the present study was conducted to evaluate the effects of shelling method and packaging materials (plastic punnet and LDPE bag) on different quality attributes of fresh sweet corn kernels during storage under refrigerated conditions.

Sweet corn kernels shelled by hand operated fresh sweet corn sheller and also manually (hand) shelled kernels were packed in two packaging materials of 100 gauges *viz*., LDPE bag and plastic punnet. Quality characteristics were determined by quantitative measurement of physiological weight loss, moisture content percent, colour and hardness of sweet corn kernels. Sensory attributes like color, texture, flavor and overall acceptability were assessed using nine point hedonic scale.There was decreasing trend in almost all the quality parameters of sweet corn kernels with increase in storage time. Minimum changes in quality parameters of fresh sweet corn kernels shelled by hand operated sheller and manually shelled sweet corn kernels packed in LDPE packaging material and stored at refrigerated condition up to 10 days.

Keywords: *Refrigerated Storage Condition, Packaging Material, Shelled Sweet Corn Kernel and Quality Parameters.*

Introduction

Corn is the most important cereal next to wheat and rice and it is widely distributed throughout the world. India occupies 5th place in average under maize/corn in the world. Sweet corn is a variety of maize with high sugar content. Sweet corn is an important source of carbohydrates, protein, iron, fiber, vitamin 'B' and minerals. Nutritionally, sweet corn contains 60 to 68% starch and 7 to 15% protein. An opaque seeded type corn is more nutritious and contains a high percentage of essential amino acids. The embryo which forms about 12% of the whole grain is source of protein, fats and sugars.The kernels of sweet corn are much sweeter than normal corn, namely 25 – 30% (Mariusz *et.al.* 2015). Fresh sweet corn kernels content very high moisture content. Kernels losses its texture and taste after shelling. The suitable packaging material helps to preserve its quality during handling and storage. Assessment of different quality attributes helps to evaluate the suitability of packaging material and in the assessment of shelf life of sweet corn kernels during storage. Therefore, the present study was conducted to evaluate the effects of shelling method and packaging materials (plastic punnet and LDPE bag) on different quality attributes of fresh sweet corn kernels during

Materials and Methods

Freshly harvested sweet corns (Zea mays, L.) were procured from local market. Plastic punnet made up of PET (polyethylene terephthalate) is a strong, versatile container and offer clear product visibility. Punnet (10 x 7 x 3 cm) and low density polyethylene of 100 gauge thickness (8 x 10 cm^2) was used for packaging of sweet corn kernels with 0.036 % perforation. Perforations were created in the pouches by punching holes (Koraddiand sumagala 2016).

Sweet corn cobs were shelled by hand operated sweet corn sheller. Kernels free from mechanical damage were packed into two packaging material i.e. plastic punnet and LDPE bag. Packed kernels were stored in refrigerated condition (4°C and 90% RH) (Avila *et al.*, 2007). Manually shelled sweet corns kernels were stored as control to compare the quality parameters during storage.

Treatments: T_1 - Machine shelled sweet corn kernels packed in Plastic punnet.

T_2 - Machine shelled sweet corn kernels packed in LDPE bag.

T_3 - Manually (hand) shelled sweet corn kernels packed in plastic punnet.

T_4 - Manually (hand) shelled sweet corn kernels packed in LDPE bag

Quality Assessment

Physiological Loss in Weight (PLW): Physiological loss in weight was calculated by considering initial and final weight of the sample on first and observation day respectively and expressed in percentage.

Moisture Content (%): The percentage moisture content was calculated using the air oven method.

Colour: Colour was assessed by using a Hunter Colorimeter on the basis of L* value.

Hardness: The textural quality of sweet corn kernel was measured by TA-XT plus texture analyser.

Sensory Evaluation

Sensory attributes like color, texture, flavor and overall acceptability were assessed using nine point hedonic scales for all samples. All indexes were measured from 0 to 9, where a score of 9 represents excellent quality and 0 represent the lowest quality level (Shao and Li, 2011).

Results and Discussion

Colour and Texture

The degree of colour and texture liking was higher in treatment T_2 i.e. machine shelled kernels packed in LDPE bag than plastic punnet. Among all the treatments, machine shelled kernels stored in LDPE bag was better in texture up to 11th day of refrigerated conditions. Samples of treatment T_3: Manual (hand) shelled and T_1: Machine shelled sample both stored in plastic punnet were discarded on 6th and 2nd day by judges due to the loss of moisture.

Flavour and Overall Acceptability

Maximum scores for flavor were obtained by the treatment T_2: machine shelled samples packed in LDPE bag as compared to plastic punnet. Manually (hand) shelled kernels stored in plastic punnet was discarded by judges on 7th day at refrigerated storage condition.

Overall acceptability of machine and manually (hand) shelled sweet corn kernels stored in both packaging material decreased with increase in storage period. It was observed that treatment T_3: manually (hand) shelled samples stored in plastic punnet showed lowest score during storage. Overall acceptability of machine and manually (hand) shelled sweet corn kernels stored in both packaging material decreased with increase in storage period. Machine shelled and manually (hand) shelled sweet corn kernel packed in LDPE bags at refrigerated storage conditions were acceptable up to10 days.

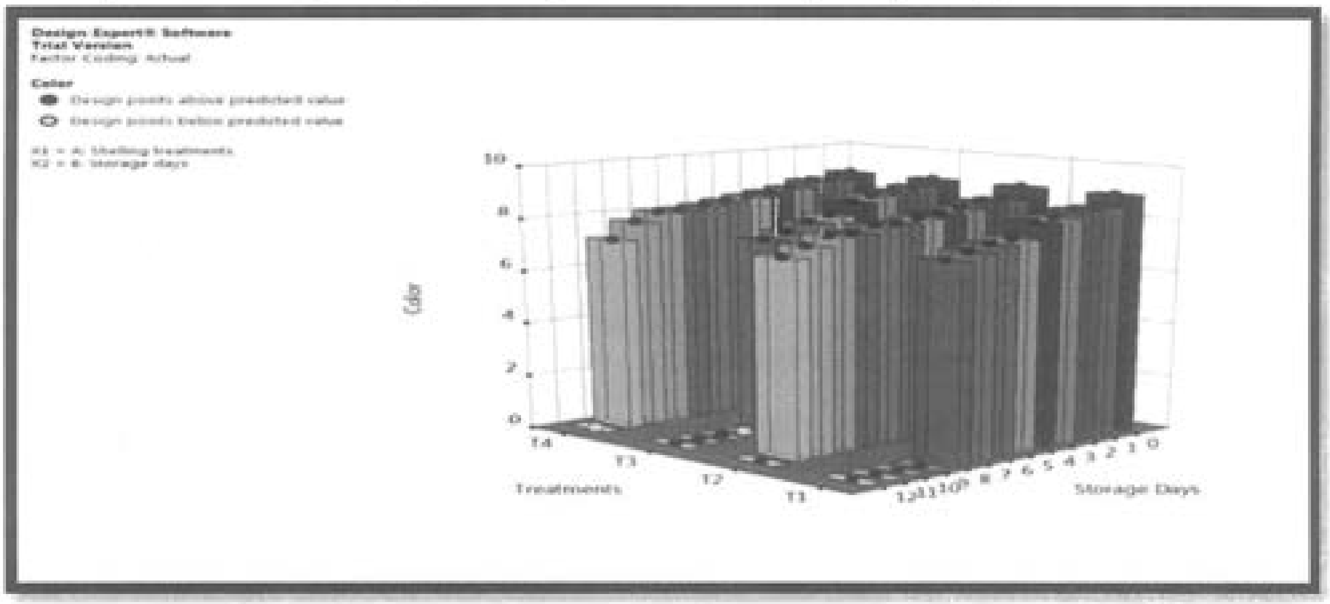

Fig 1 : Effect of shelling method and packaging material on color of sweet corn kernels stored at refrigerated condition.

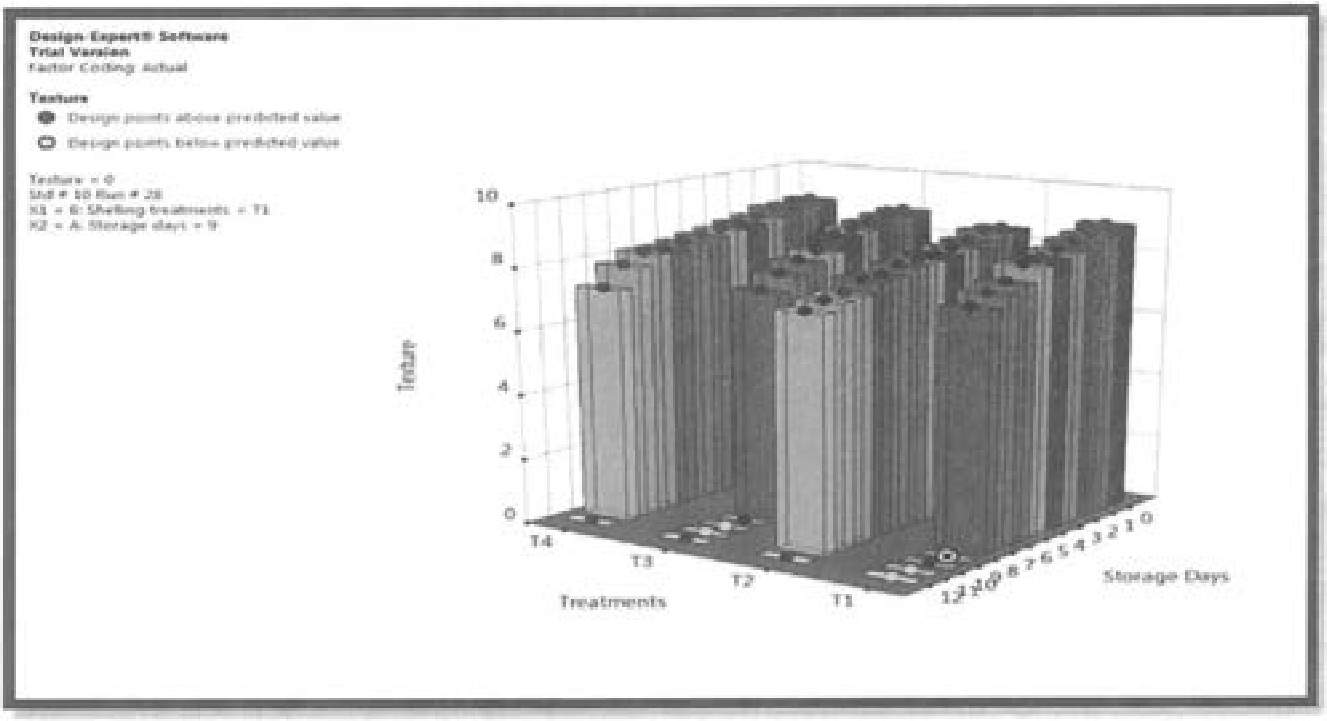

Fig. 2 : Effect of shelling method and packaging material on texture of sweet corn kernels stored at refrigerated condition.

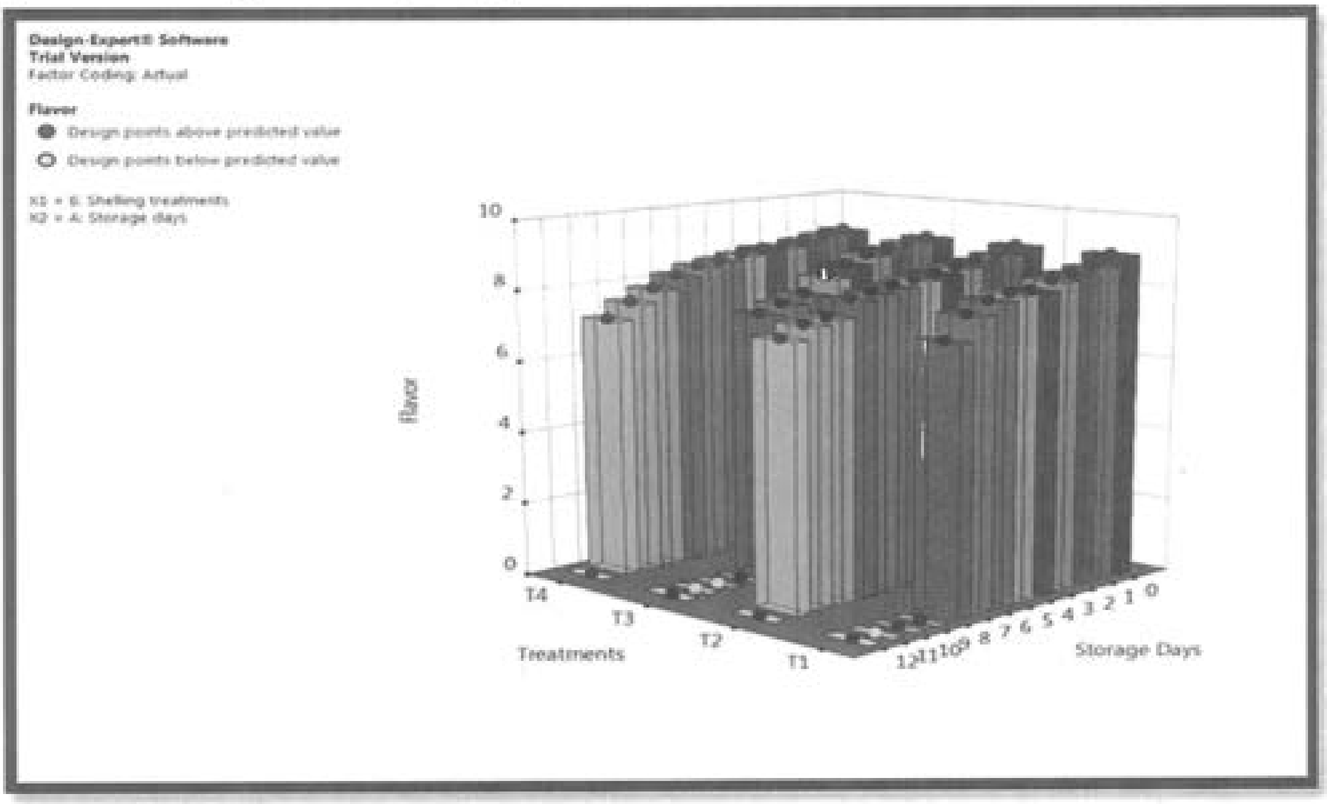

Fig. 3 : Effect of shelling method and packaging material on flavor of sweet corn kernels stored at refrigerated condition

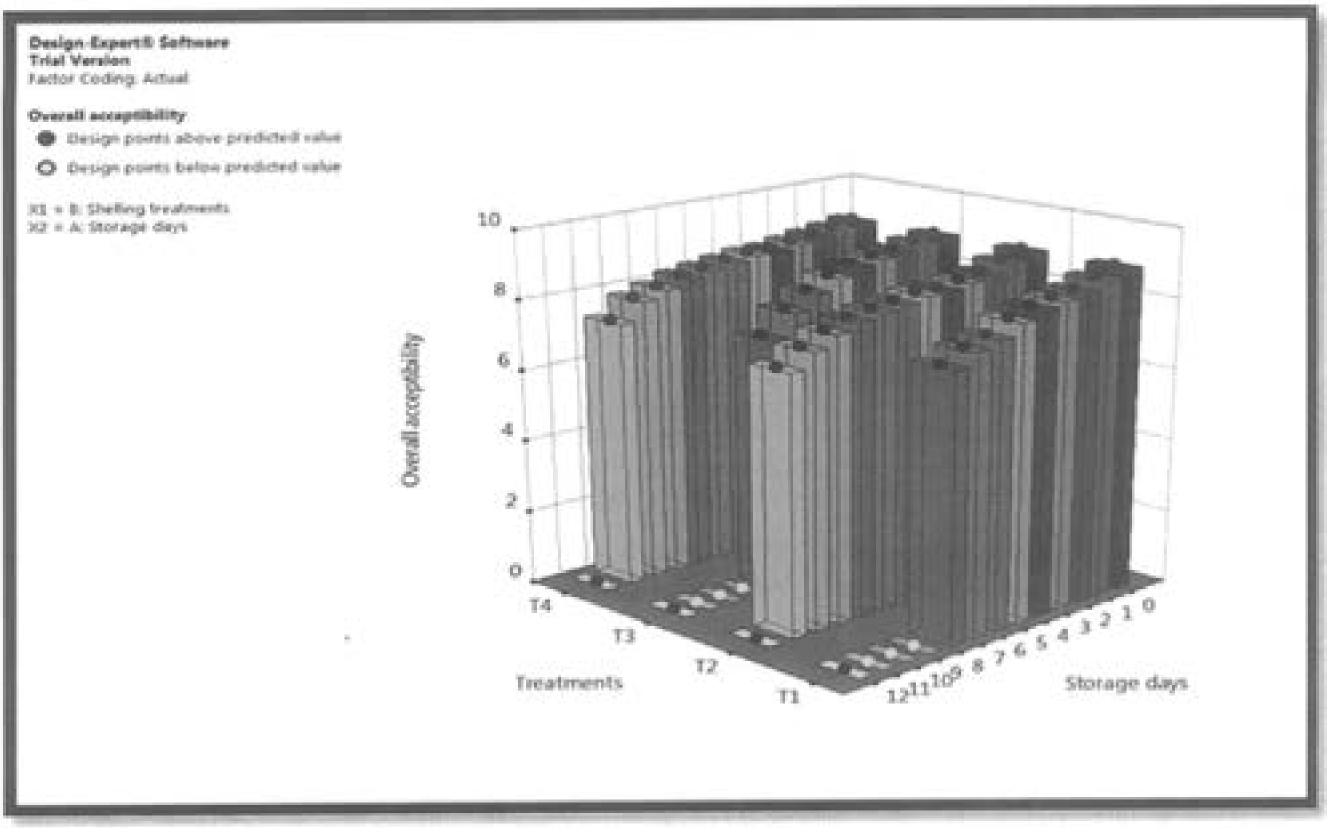

Fig. 4 : Effect of shelling method and packaging material on overall acceptability of fresh sweet corn kernels stored at refrigerated condition.

Physiological Weight Loss (%)

For manually (hand) and machine shelled sweet corn kernels weight loss varied between 0.30 % to 18.80 % and 0.29 % to 16.15 respectively, during storage. The treatment T_3 showed highest physiological weight loss (16.15 %) followed by treatments T_1 (3.15%) during storage period. Physiological weight loss (%) was minimum in LDPE i.e. and T_3 for both shelling methods. Weight loss increased with increase in storage period for all packed samples.

Moisture Content (%)

The measured value of moisture content of sweet corn kernels varied from 69.43 % to 69.65 %, during 10 days of storage.The rate of loss in moisture content of the entire sample was varied significantly with packaging material. Maximum 7 % water loss is considered as acceptable limit. The main reason for moisture loss is transpiration that occurred primarily in the kernels which in turn incur moisture loss from kernels in the form of water vapor (Scott and Elridge, 2005).

Colour

The L* colour values affected by storage time, which indicates decrease in lightness value. Sweet corn kernels in treatment T_2: machine shelled kernel packed in LDPE bag showed least change in L* colour values i.e. 60.38 while the maximum change i.e. 60.28 found in L* color values found in treatment T_1. Colour degradation is prevented by storing sample in proper pack. Because film permeability always played an important role in preventing these degradation changes (Ibrahim *et al*., 2005).

Firmness

Firmness of sweet corn kernels is a parameter that ultimately determines the quality of sweet corn kernels. Maximum firmness value i.e. 156.7 was observed for the sweet corn kernels shelled by hand operated sheller and stored in LDPE bag followed T_4: manually (hand) shelled kernel stored in LDPE bag.

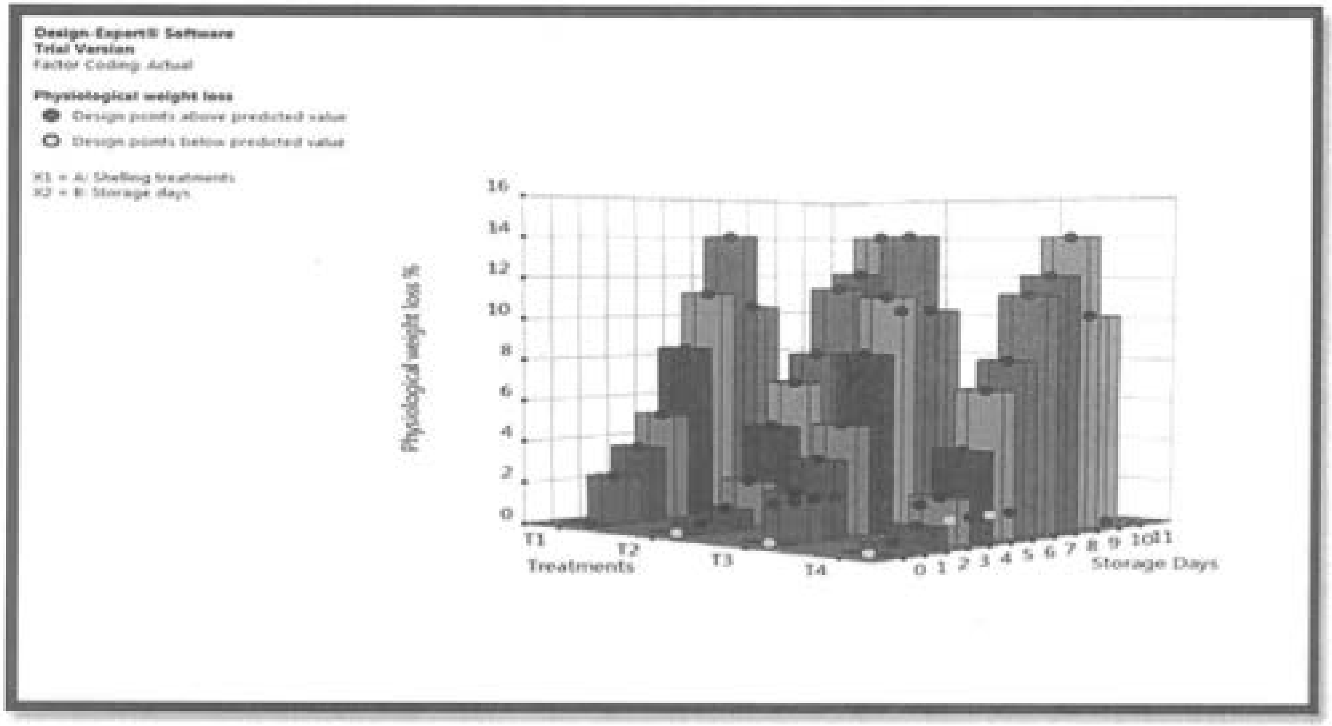

Fig. 5 : Effect of shelling methods and packaging materials on physiological weight loss (%) of shelled sweet corn kernels stored at refrigerated condition

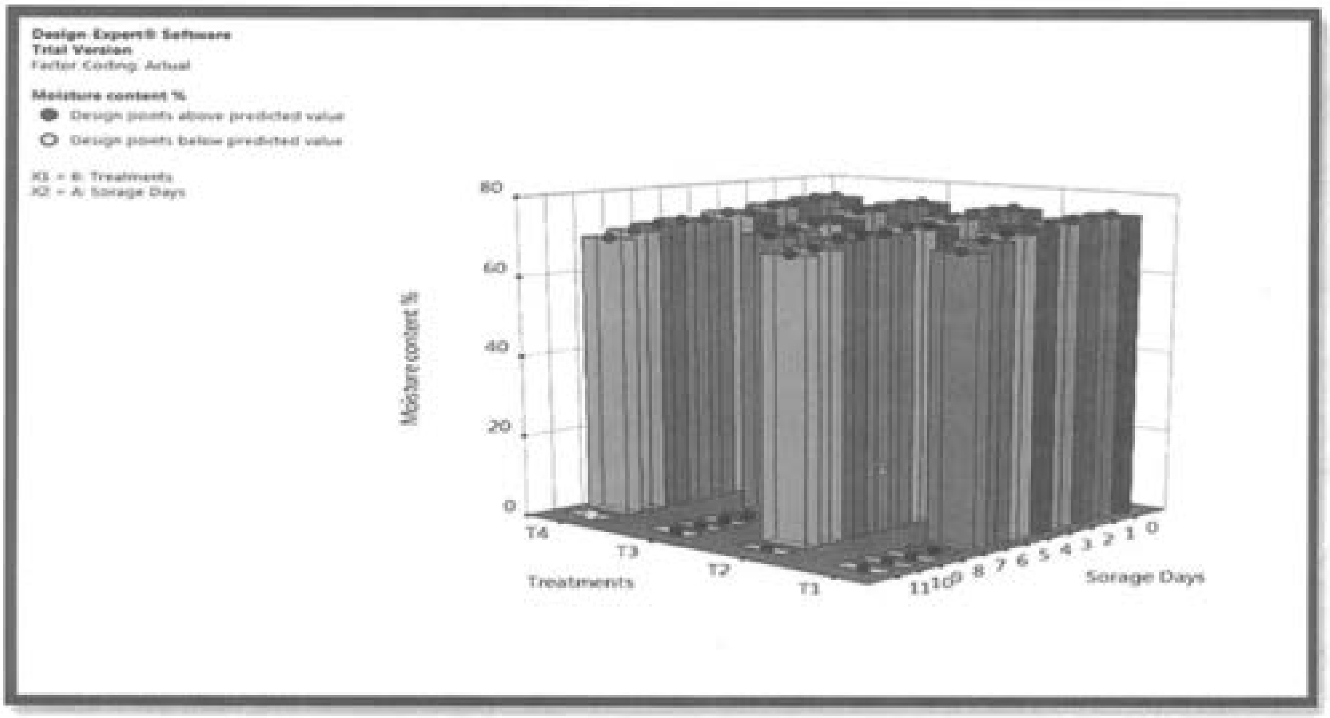

Fig. 6 : Effect of shelling methods and packaging materials on moisture content (%) of shelled sweet corn kernels stored at refrigerated condition.

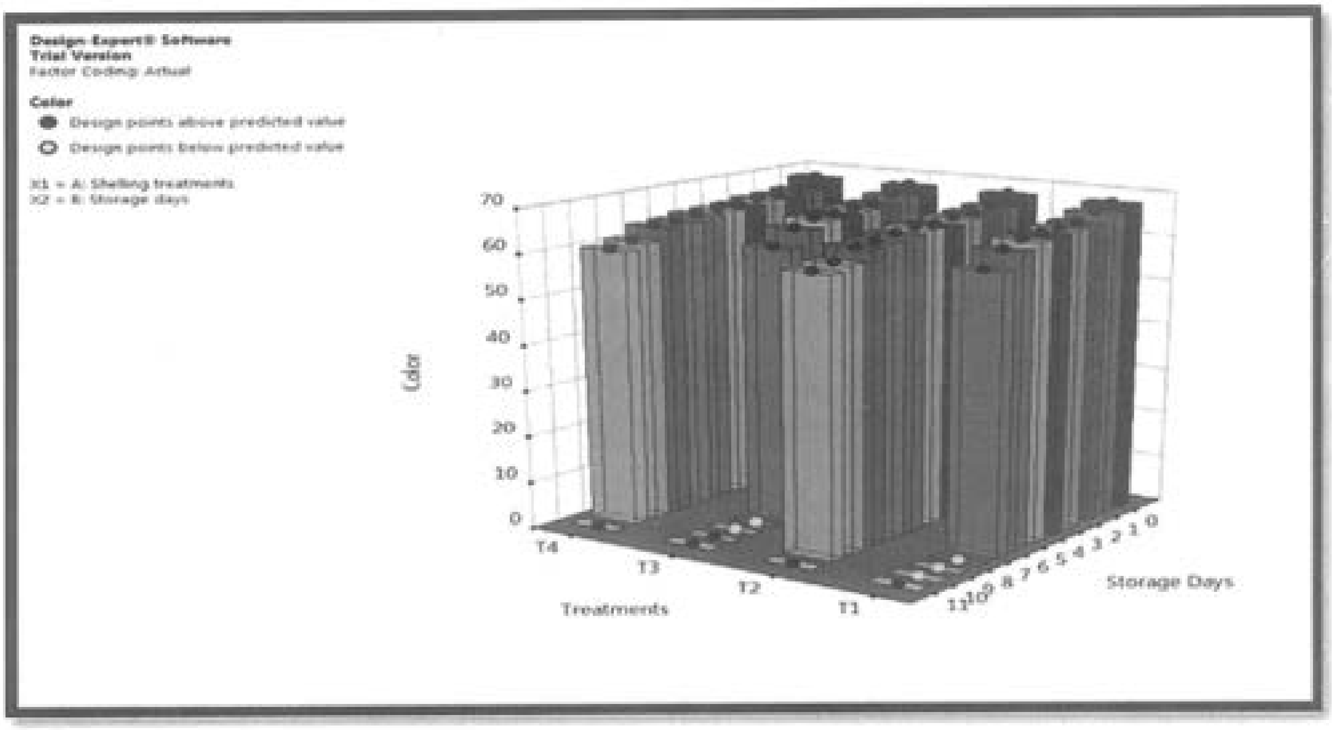

Fig. 7 : Effect of shelling treatments and packaging methods on colour changes of sweet corn kernels stored at refrigerated condition.

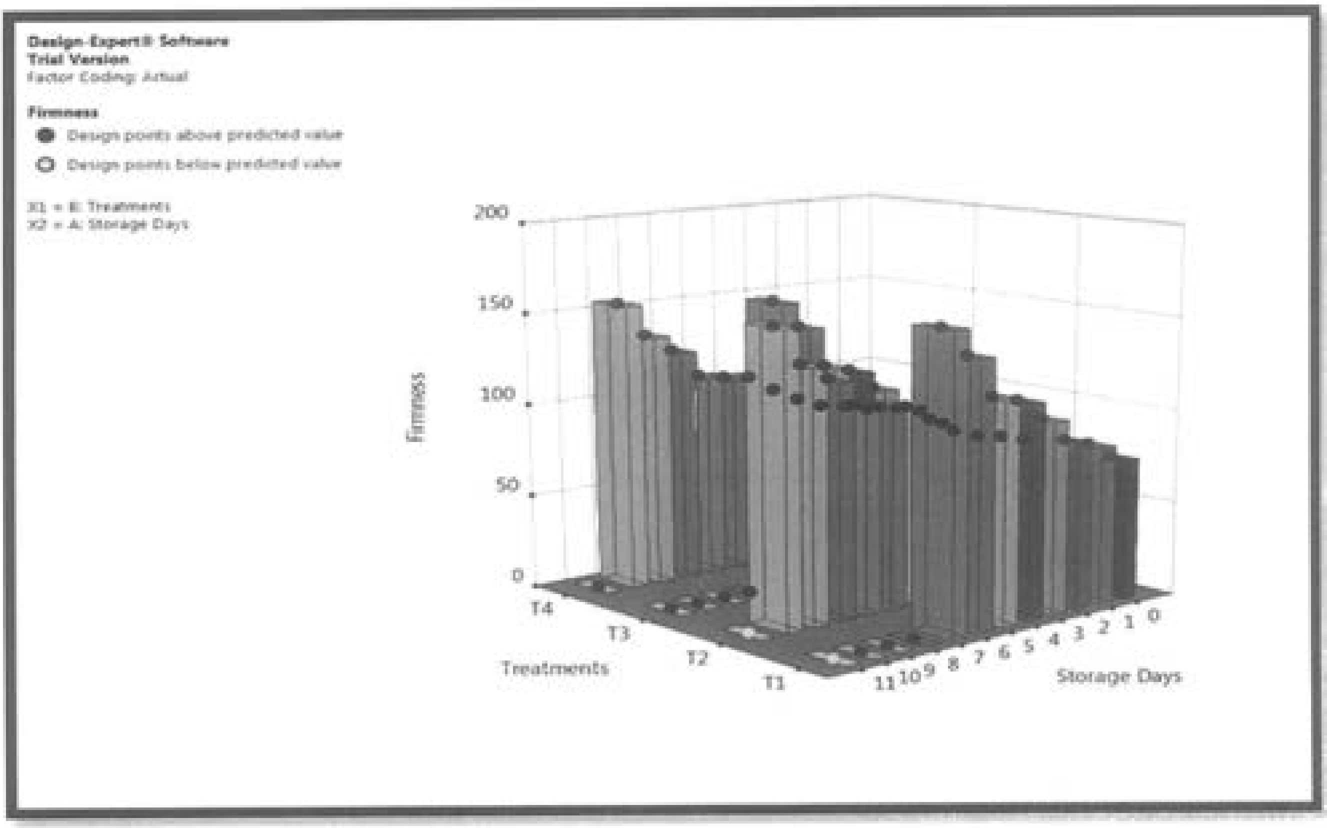

Fig. 8 : Effect of shelling methods and packaging materials on firmness changes of sweet corn kernels stored at refrigerated condition

Conclusion

LDPE packaging material was found better than plastic punnet in storability of shelled sweet corn kernels. Maximum shelf life of 10 days was observed for machine shelled sweet corn kernel packed in LDPE bags at refrigerated storage conditions.

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Design Consideration in Battery Electric Vehicle Operated Weeder

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Abstract: Weeding operation is most important intercultural operations. To overcome the limitations of traditional method of weeding, limited stock of fossil fuel and their increasing cost, it becomes necessary to switch toward eco-friendly Battery Electric Vehicle (BEV) for farming operations. The power requirement for a low-cost BEV weeder was estimated in the present investigation. It was estimated that the mass of the BEV weeder was 32 kg for which theoretical torque requirement was calculated as 71.14 N-m at maximum speed of 4 km/h. The selected BLDC motor of 350 W, 24 V with 3000 rpm was found capable to propel the vehicle as it developed the maximum tractive effort 366.93 N than the required (295.59) with a gear ratio of 50:1.

Introduction

A weed is defined as "Any plant growing where it is not wanted" (Anderson *et al.*, 1996). Weeds are a major obstruction to crop because of their ability to compete for resources with plants. Therefore, weeding operation is most important intercultural operations which aims at controlling unwanted plants. At present farmers used traditional bullock drawn or power operated weeders. It requires lot of drudgery in the operations. Whereas, engine operated weeders consume fossil fuels and liberates heat, noise and harmful exhaust gases causing in pollution. To overcome theselimitations of traditional weeding operationsan eco-friendly BEV are expected to make a revolutionary change in the market because of nonexistence of uncomplimentary materials such sulphur, nitrogen, polycyclic aromatics and air pollution (Lee et al. 2004).

Also, BEV technologies have been gaining importance despite they have higher cost, their higher energy efficiency, lower emissions, regenerative braking and silent mode drive capabilities are major advantages over conventional vehicles. Such types of latest technologies are now days commercially available which can be tried in agriculture for developing various equipment such as weeder. So, an attempt has been made to design the BEV weeder using mass configuration.

Material and Methods

Design of driving system

The drive system of BEV weeder comprises of an DC motor which is drive axel integral part, power battery, motor controller, power transmission system (Chain and sprocket type) and drive wheel. When BEV work, by operating the switch, the operator sends the signal instruction to the whole vehicle drive system, it transmits the signal instruction to the battery and the DC motor connected with motor controller. Further, the DC motor transmits the power to the driving wheel by the power transmission system. Fig. 1 shows schematic sketch of driving system for BEV weeder.

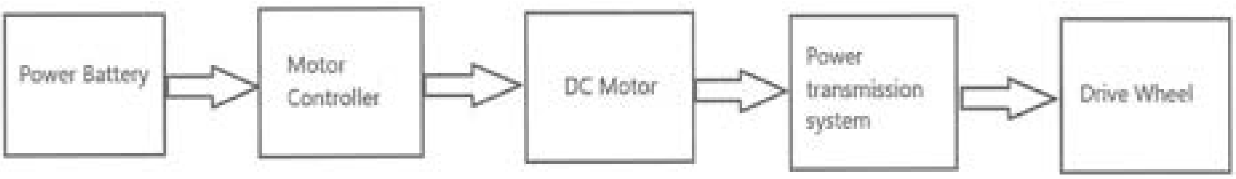

Fig. 1 : Schematic sketch of driving system for BEV weeder.

The BEV weeder was designed with an aim of traversing between the row crops of 45 cm spacing with wide variety of field conditions hence it is decided to develop a vehicle on 3 km/h speed on load and maximum speed was kept as 4 km/h for no load while in transport. Considering the same Table 1 summarized the data on the specification for the vehicle outlining information need to calculate the power requirements for the drive unit.

Table 1: Specification of BEV weeder

Sr. No.	Specification	Measures	Unit
1	Weight of vehicle	32	kg
		314	N
2	Field working speed	3	Km/h
		0.83	m/s
3	Maximum speed	4	Km/h
		1.11	m/s
4	Acceleration (a)	0.74	m/s^2
5	Number of driving wheels	1	no.
6	Drive wheel radius (Rw)	0.125	m
7	Length	0.99	m
8	Width	0.66	m
9	Height	0.1	m
10	coefficient of rolling resistance (Soft grass) (Chauhan, 2015)	0.075	
11	Grade or inclination angle, (Chauhan, 2015)	2	degree
12	Static friction (Kepner *et al*, 2005)	0.4	

Design calculations of BEV powertrain

Considering all acting forces and parameters of the BEV powertrain should be coupled with the wheel rotational velocity and surface forces as well as for deriving the expressions for the acting forces. Therefore, to calculate total tractive effort i.e., power required to propel BEV is given as follows (Chauhan 2015)

$$TTE = F_{rr} + F_{hc} + F_a \qquad \ldots(1)$$

Where, TTE is the total tractive effort, Frr is the force necessary to overcome rolling resistance, F_{hc} is the force necessary to overcome inclined surfaceand F_a is the force required accelerating to final velocity.

Factors affecting the required torque

When selecting drive motor for the electric vehicle, several factors must be considered as shown in Fig. 2 to determine the maximum torque required. These factors are:

1. Rolling resistance 2. Grade resistance 3. Acceleration force

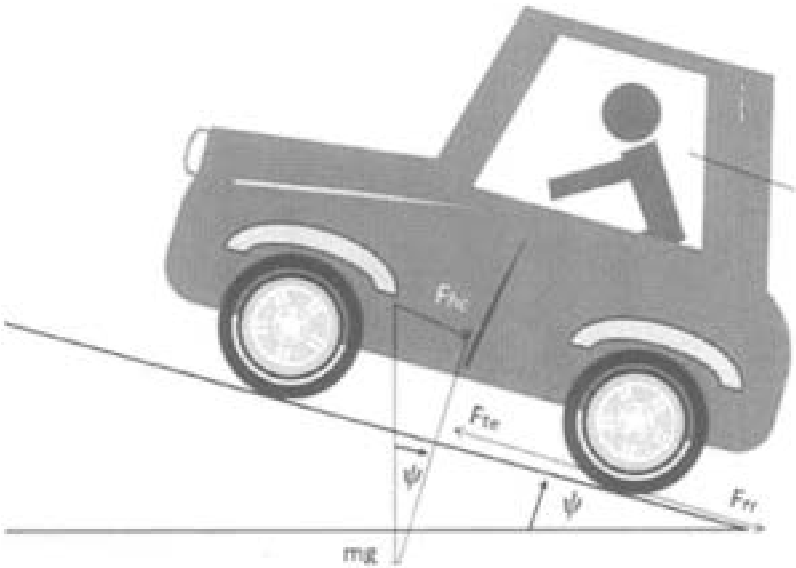

Fig. 2 : Forces acting on moving vehicle

Calculation of the rolling resistance

Rolling Resistance is the opposing force that the vehicle needs to overcome to propel over a surface and which is computed by using following equation.

$$F_{rr} = W_{GV} \times C_{rr} \qquad ...(2)$$

Where, $F_{rr}$the is force necessary to overcome rolling resistance, W_{GV} is the gross vehicle weight and C_{rr} is the co-efficient of rolling resistance. Putting Values from Table 1 in eq. 2

$$F_{rr} = 32 \times 0.07 = 24 \text{ kg} \times 9.81 = 23.54 \text{ N}$$

Calculation of the grade resistance

Grade resistance is amount of force necessary to move a vehicle upon the slope or grade.

$$F_{hc} = W_{GV} \times \sin \psi \qquad ...(3)$$

Where, $F_{hc}$is the force necessary to overcome inclined surface, kg, ψ is the grade or inclination angle. Putting Values from Table 1 in Eq 3

$$F_{hc} = 32 \times \sin 2° = 1.16 \text{ kg} \times 9.81 = 10.95 \text{ N}$$

Calculation of the acceleration force

Acceleration force is the force that is necessary for vehicle to accelerate from a stop to maximum speed in a desired time. It is calculated as

$$F_a = m \times a \qquad ...(4)$$

Where, m is W_{GV} / g, $F_a$is the acceleration force, m isthe mass of the vehicle, g is the acceleration due to gravity (9.81 m/s^2) and a is theacceleration. Theacceleration time was taken 1.5 s to get the maximum speed. Thus, Eq.4 becomes

$$F_a = 3.26 \times 0.74 = 2.41 \text{ kg} \times 9.81 = 23.66 \text{ N}$$

Finding the total tractive effort

To select electric motorwhich produce enough torque to propel the vehicle, it is very important to calculate total tractive effort. Therefore, from Eq1 the total tractive effort can be calculated as

$$TTE = F_{rr} + F_{hc} + F_a$$
$$= 23.54 + 10.95 + 23.66 = 58.15 \text{ N}$$

Determination of wheel motor torque

To determine whether vehicle will perform as designed regarding tractive effort and acceleration, it is necessary to calculate wheel motor torque

$$\tau = R_f \times TTE \times r_{wheel} \qquad ...(5)$$

Where,τisthe wheel motor torque,TTE is the total tractive effort,R_f is the resistance factor, it is considered as 1.15 and r_{wheel} is the radius of drive wheel. By putting the values in Eq5

$$\tau = 1.15 \times 58.15 \times 0.225 = 15.04 \text{ N-m}$$

Determination of maximum tractive torque

It is necessary to verify if the wheels of the vehicle are capable enough to transmit the required amount of torque for that the maximum torque that can be transmitted through the wheels need to be calculated. The maximum torque is given as:

$$\tau_{max} = W_w \times \mu \times R_W \qquad ...(6)$$

Where, τ_{max} is maximum tractive torque,μ is the co-efficient of static friction and$R_W$istheradius of drive wheel. Putting the values from table 1 in Eq6

$$\tau_{max} = 32 \times 0.4 \times 0.225 = 2.88 \text{ kg} \times 9.81 = 28.25 \text{ N-m}$$

For satisfactory performance of the vehicle,

$$\tau_{max} \geq \tau$$

i.e., 28.25 N-m > 15.04 N-m

Calculating the motor power requirement.

It assumed that a 350 W, 3000 rpm BLDC motor is capable to drive the vehicle. To the check suitability of motor specification, it is necessary to check load calculations. Therefore, the power requirement is calculated as

$$P = \frac{2\pi NT}{60} \quad \text{...(7)}$$

Where, P is Power, N is motor speed rpm and Tis torque. By putting the values, we have

$$T = \frac{60 \times 350}{2\pi \times 300} = 11.14 \text{ N-m}$$

Consider, maximum velocity of the BEV weeder as 1.11 m/s, velocity is written as

$$V = Rw \times \omega \quad \text{...(8)}$$

Where, V is velocity, R_w is radius of wheel and ω is angular momentum.

$$\omega = \frac{V}{Rw} \quad \text{...(9)}$$

$$= \frac{1.11}{0.225} = 4.93\ rad/s$$

Motor speed is calculated as,

$$\omega = \frac{2 \times \pi \times N}{60} \quad \text{...(10)}$$

$$N = \frac{4.93 \times 60}{2\pi} = 47\ rpm$$

On this rpm, the available torque on shaft is,

$$T = \frac{60 \times P}{2\pi N} \quad \text{...(11)}$$

$$= \frac{60 \times 350}{2\pi \times 47} = 71.14 \text{ N-m}$$

Design of power transmission system

The motor speed is reduced from 3000 rpm to 300 rpm in first stage of power transmission by using speed reduction unit itself. Considering 75 % transmission efficiency, we get the N_1 rpm as

$$N_1 = 0.75 \times N = 0.75 \times 300 = 225 \text{ rpm}$$

In second stage of power reduction is done using chain and sprocket mechanism. Therefore,

$$\frac{N_1}{N_2} = \text{speed ratio} \quad \text{...(12)}$$

Assume a gear ratio to be 5:1 to get the desired torque for an electric vehicle. Therefore,

$$\frac{N_1}{N_2} = 5$$

$$N_2 = \frac{225}{5} = 45$$

Now considering transmission efficiency as 90 % we get final rpm as,

$$N_3 = 0.9 \times N_2 = 0.9 \times 45 = 40.5 \text{ say } 40 \text{ rpm}$$

Calculating torque at drive wheel

Torque at wheel on final rpm is calculate as,

$$T_w = \frac{60 \times W}{2 \times \pi \times N_2} \quad \ldots(13)$$

$$= \frac{60 \times 350}{2 \times 3.14 \times 40} = 82.56 \text{ N-m}$$

Now velocity at wheel is given by

$$v = \frac{\pi \times d \times N_2}{60} \quad \ldots(14)$$

$$= \frac{3.14 \times .450 \times 40}{60} = 0.94 \text{ m/s}$$

The tractive effort developed by the motor is calculated as

$$F_t = \frac{T_w}{R_w} \quad \ldots(15)$$

$$F_t = \frac{82.56}{0.225} = 366.93 \text{ N}$$

Calculation of draft and power requirement of weeder

Assume, Unit draft of the soil is assumed 0.4 kg/cm^2(Sharma and Mukesh, 2008)

Width of the sweep is 30 cm, Depth of the soil is 4 cm

$$\text{Draft} = \text{Soil resistance} \times \text{Cross sectional area of cut} \quad \ldots(16)$$

$$= 0.40 \times \frac{1}{2} \times 30 \times 4 = 24\ kg = 235.44\ N$$

Power requirement for BEV weeder is computed by using

$$Power = \frac{Draft \times Speed}{75} \quad \ldots(17)$$

Consider speed of operation = 3 km/h = 0.83 m/s

$$Power = \frac{24 \times 0.83}{75} = 0.26 \text{ hp} = 0.19 \text{ Kw}$$

Therefore, total tractive force required to drive the wheel is

Total tractive force required = TTE + draft of weeder ...(18)

Putting value in from equation 3.1 and equation 3.16 in above eq

= 58.15 + 235.44 = 293.59 N

Result and Discussion

The motor torque must be greater than or equal to the computed wheel torque while selecting the motor. i.e. (28.25 N-m≥ 15.04 N-m). The maximum tractive torque represents the maximum amount of torque that can be applied before slipping occurs for each drive wheel. Therefore, in this case it satisfies the all conditions. The maximum tractive force developed by motor (366.93 N) which were higher than the required total tractive force calculated (293.59 N). Hencea 24 V, brushless DC motor of 350 W, 3000 rpm was selected with gear reduction of 50:1 is suitable for the BEV weeder.Also, if while working in field condition if any unexpected increase in load occurs, motor can sustain the load till 1.24 % of rated TTE.

Conclusions

1. Selecting an electric motor is the most important parameter of the BEV as it depends on the estimated weight and staring effort required to move the BEV. In the present investigation a BLDC motor was found suitable because of its small size and less weight with high torque.
2. Power is reduced from 3000 rpm to 40 rpm for weeding operation. Hence the speed ratio of the DC motor to drive wheel is given as

   Speed ratio from DC motor to drive wheel = 50 :1

3. The maximum tractive force developed by motor which were higher than the required total tractive force. Therefore, selected motor is found suitable for BEV weeder.

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Development of Dual Axis Fresnel Lens Solar Concentrator System for Cooking Application

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Abstract: The Solar Fresnel lens system was developed at Department of Unconventional Energy Sources & Electrical Engineering, Dr. PDKV, Akola.,(MH). The dual axis Fresnel lens solar concentrator (FLSC) system was integrated with dual axis control panel system, lens, heat exchanger, cooking pot with fluid pipe network and insulation. The study on dual axis solar Fresnel lens system was conducted for cooking application. Three type of oil were used having oil code 66, 68 and 15W40 for heat supply on indirect mode to the cooker. Among these the thermal performance of oil type 66 was found to be best as it achieved maximum temperature of 135℃ in winter and 145℃ in summer season, respectively in 2 lit cooking pot. During the test run three types of flow rates were maintained as 0.5, 1 and 1.5 lpm in which the maximum heat achieved at flow rate of 1.5 lpm. also, three type of focal length were used for the performance was evaluated at focal length 1450, 1650 and 1850 mm for testing maximum temperature at focal point on heat exchanger to supply heat in cooking pot.

Keywords: Fresnel lens, solar radiation, cooking pot, solar cooker, oil flow rate, dual axis.

Introduction

Fresnel lens is used to collect solar radiation and spot it on small area for indirect cooking. Fresnel lens made from plastic and polymeric plastic silicon and also available cheaply and repayable rate as compare to glass lens. The dual axis solar tracking system for indirect type of cooking system would be beneficial for improving thermal performance of the cooker

Materal and Methods

Components of the developed System

The dual axis Fresnel lens solar concentrator (FLSC) system was integrated with dual axis control panel system, lens, heat exchanger, cooking pot with fluid pipe network and insulation. The fabrication process and details of each component is given below.

Control panel of dual axis tracking system

In FLSC system the solar rays are falls on Fresnel lens which is based 2-axis solar tracking system. In two axes tracking system basically includes four sensors at four side of the LDR which are means Light dependent resistor. The four sensors are including for purpose of automatic tracking. In which two sensors for tracking sun rays in X-direction means in East West direction, other two sensors for tracking sunrays in Y-direction. During tracking the sensors sense the sunrays in both direction simultaneously and keep the frame on which the Fresnel lens is attached and along with that the whole assembly in proper direction to get maximum intensity of sunrays. Then rays fall on Fresnel lens and concentrate at focal point. The focal point exactly located on heat exchanger which copper tube, where the oil is continuously circulating in the copper tube. The copper tube is placed in heat exchanger which is attached to the frame in such a manner that the focal point is always remains on heat exchanger and gets continuous hot oil supply. This tube is heated by means of more concentration of solar rays without any reflection; due to this oil which is through copper tube is heated. This heated oil enters into the jacketed cooker having temperature range of 135 °C to 145 °C. (Plate 4.1).

Fresnel lens

Fresnel lens is made up from polymetric plastic silicon which was 1130 × 1140 mm size with an area 1 m^2 and diameter of 112 cmand depth of the each groove is 0.5 mm it bear heat up to 58°C in operation shown in Plate 4.2.

Heat exchanger

A heat exchanger is a device used to transfer heat of fluid from one fluid to another.It is an important process for most of the chemical industries. There are varieties of heat exchanger direct transfer, or simply recuperates and indirect type. The heat duty of the cooking was estimated to be 134 *kcal/h.* To match up the heat duty heat exchanger area was found to be 0.0625 m^2as shown in plate 4.3.

Solar cooking pot

It is a device used to cook food material by using only solar radiation and can save convectional fuels to a significant amount. It is the simplest, safest and most convenient way of cooking a food without consuming fuel or heating up in the kitchen. In this research work indirect type cooker of capacity 2 liter was used for the trial and it s shown in plate 4.4.

Plate 4.1 Control panel of dual axis tracking system

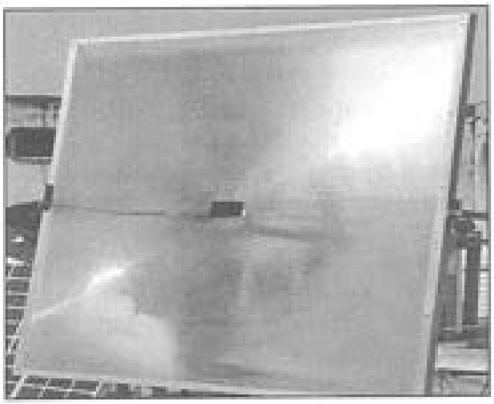


Plate 4.2 Fresnel lens

Plate 4.3 Heat Exchanger

Plate 4.4 Cooking pot

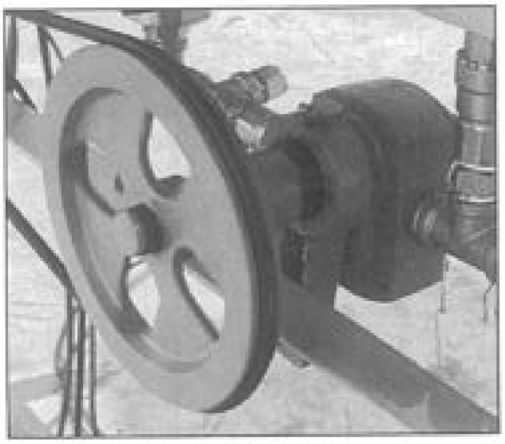


Plate 4.5 Hot oil circulation pump

Plate 4.6 Glass wool insulation

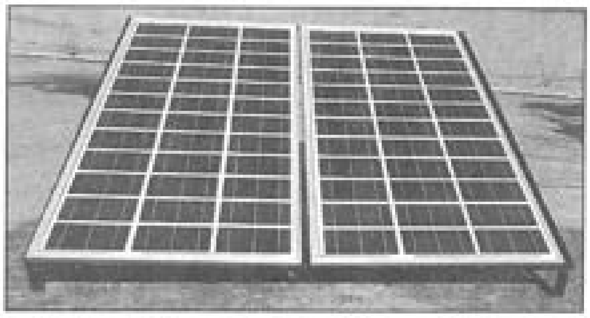


Plate 4.7 Solar photovoltaic panel

Hot oil circulation pump

Pump is a device to circulate hot oil throughout the FLSC system for heating purpose to transfer heat in order to cook the food material. Maximum capacity of the pump for circulation of oil was 5 liter per hour. The motor power requirement as per design calculation of the pump was 90 watt and shown in Plate 4.5.

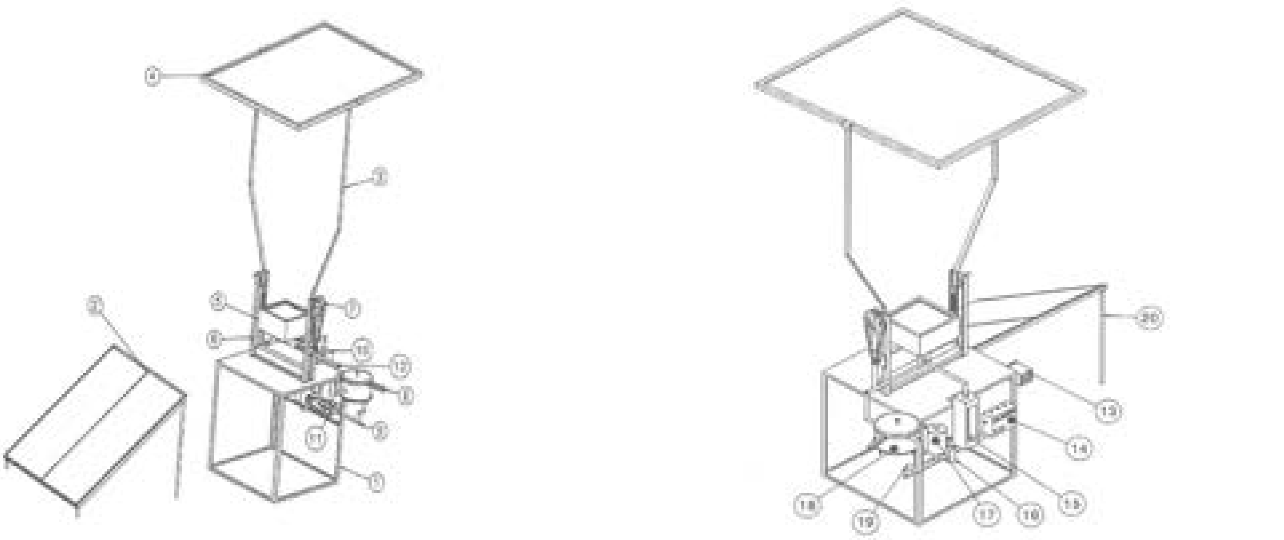
Insulation material

Glass wool insulation is one of the forms of insulation used world-wide because of its thermal and acoustic properties, light weight, high tensile strength and exceptional resilience. Glass wool is one of the most dominant type of insulation preferred in thermal applications with service temperatures ranging up to 250°C. Glass wool consist of fine, long, inorganic fibers bonded together by high temperature binder. Due to tiny pockets of air in it, it creates an excellent thermal and acoustic insulation. The light weight of glass wool also offers significant advantages during transport and installation. In addition, glass wool is chemically inert and has no impurities such as iron shots, sulphur and chloride. The product is non corrosive to metal and does not support mold grow.

In the system glass wool was used as an insulation material for wrapping on fluid pipe network to reduce heat losses and to increase the life of fluid pipe. The thickness of glass wool was maintained as 2.5 cm with thermal conductivity of 0.04 $Wm^{-1}K^{-1}$ and shown in Plate 4.6.

SPV panels

A total power required for the tracking was 30 watt and for oil circulation pump 90 watt thus total 120 watt power could be generated by $90 \times 2 = 180$ watt capacity of solar photovoltaic panel and shown in Plate 4.7.



1-Frame, 2- SPV panel, 3- Connecting rod, 4- Fresnel lens, 5- Heat exchanger, 6- HE stand, 7- Motor wheel,8-Cook pot, 9- Fluid pipe, 10- Oil flow meter, 11-Hot oil pump, 12- Fluid pipe, 13- Temperature indicator, 14- Control panel of dual axis tracking system, 15- Hot oil flow meter, 16- Hot oil pump, 17- Oil tank, 18- Cook pot, 19- Fluid pipe, 20- SPV panel stand.

Fig. 1 : Isometric view of dual axis Fresnel lens solar concentrator (FLSC) system

Results And Discussion

Cooking of split green gram (Moong dal)

The 500 gm of moong dal was added in 1 liter of water and kept it for cooking. The test was started at 11 AM and within 45 min the moong dal is cooked & ready for to be tested by experts.

Table 1 : Cooking efficiency during split green gram (Moong dal)

Time(min)	Available solar radiation (W/m^2)	Temperature of water in cooking pot (°C)	Efficiency (%)
11.00	618.61	29	-
11.05	634.83	35	3.03
11.10	651.79	58	10.53
11.15	681.36	78	16.70
11.20	697.71	96	21.36
11.25	712.74	97	21.76
11.30	734.47	99	26.12
11.35	756.45	100	25.40
11.40	797.45	101	24.43
11.45	896.36	101	23.11
Average	718.17		**19.16**

Plate 5.1 Before cooking Split Green gram (Moong dal)

Plate 5.2 After cooking Split Green gram (Moong dal)

Plate 5.3 Prepared moong-dal

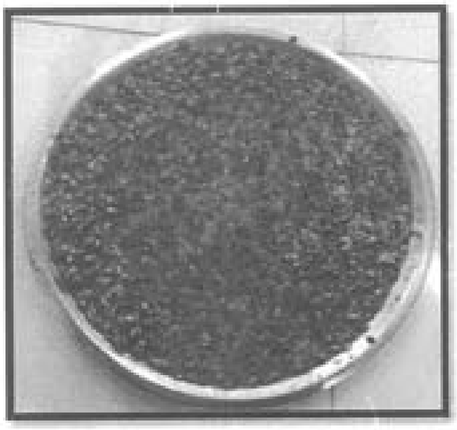


Plate 5.4 Split Green gram (Moong dal)

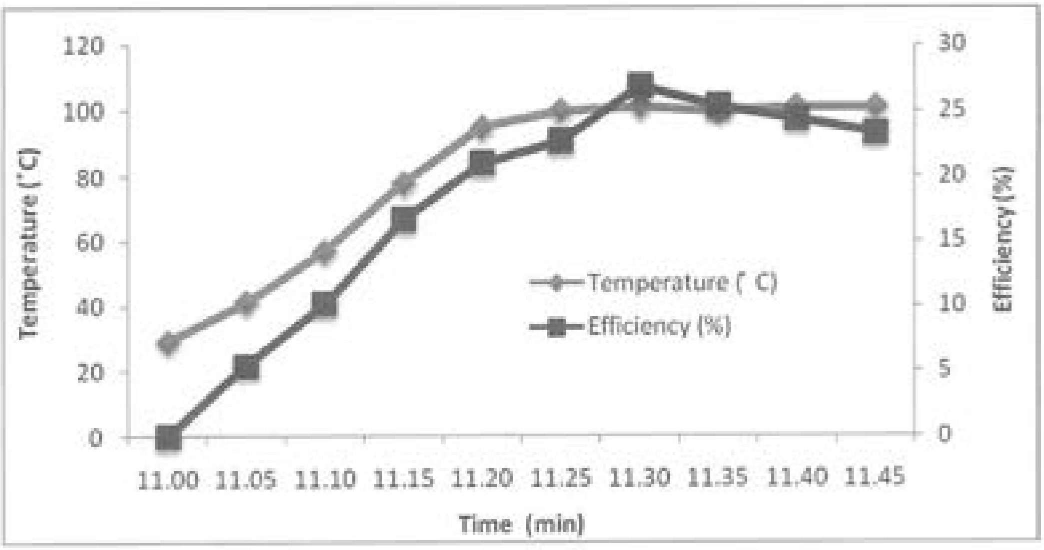


Fig 2 : Cooking efficiency during cooking of split green gram (Moong dal)

The trend of cooking temperature is shows in Table 5.45 and graphically presented in Fig. 2 water boiling start at 97℃ within time 32 minute so total time to take cook was 45 M at average solar radiation 618.17 W/m^2.The earlier study by Kalbande*et al.*in the year 2007 for cooking of green gram by using paraboloidal solar cooker was carried out and then cooked in 50 min.

Conclusion

The heat energy supplied by the lens was sufficient to achieve the desired temperature for cooking application. The automatic dual axis sun tracking system was found to be feasible to track the solarradiation. The cooking test carried out which indicate that the size of lens (1 m^2) and other designed parameters are the least possible configuration required for 2 liters size of cooking pot. Three types ofoil were used namely oil code 66, 68 and 15W40 for supply the heat to cooker and 66 type of oil was found to be best among the other by achieving the maximum temperature 135℃ in winter and 145℃ insummer season. The maximum and minimum efficiency of indirect solar cooker by Fresnel lens was found to be 27.62, 12.09 per cent respectively and can be further improved by using advance heat absorbing materials. The maximum and minimum steam temperature inside cooker was found to be 122 and 120℃ which was used to cook the any food material.

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Different Type and Digestion System of Biogas Plant

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1. Introduction

Biogas, as a mixture containing 55-65 percent methane, 30-40 percent carbon dioxide and the rest beingthe impurities(H_2, H_2S, and some N_2), can be produced from the decomposition ofanimal, plant and human Waste. It is a clean but slow burning gas andusually has a calorific value between 5000 to 5500 kcal/kg (20935 to23028 kJ/kg) or 38131 kJ/ms. it can be um cooking, reducingthe demand for firewood. Moreover, the material from which the biogasis produced retains its value as a fertilizer and can be returned to thesoil. Biogas has been popular on the name, "Gobar Gas" mainly becausecow dung has been the material for its production, hitherto. It is notonly the excreta of the cattle, but also the piggery waste as well aspoultry droppings are very effectively used for biogas generation. A fewother materials through which biogas can be generated are algae, cropresidues (agro-wastes), garbage kitchen wastes, paper wastes, seawood, human waste, waste from sugarcane refinery, water hyacinthetc., apart from the above mentioned animal wastes. Any cellulosicorganic material of animal or plant origin which is easily bio-degradable is a potential raw material for biogas production

Biogas is produced by digestion, pyrolysis, orhydrogasification. Digestion is a biclogical process a occurs in theabsence of oxygen and in the presence of anaerobic organisms at ambient pressures and temperatures of 30-70°C. The container in which digestion takes place is known as the digester.

Anaerobic digestion. Biogas technology is concerned to microorganisms. These are livingcreatures which are microscopic in size and are invisible to unaided eyes. These are different types of microorganisms. They are called bacteria, fungi, virus etc. Bacteria again can be classified into two types--beneficial bacteria and harmful bacteria. Compost making production of biogas,vinegur,etc are examples of beneficial bacteria. Bacteriacausing cholera, typhoid, and diphtheria are examples of harmful bacteria. Thistype of bacteria which causes diseaseboth in animals and human beings is called pathogen.

Bacteria can be divided into two major groups based on their oxygen requirement. Those which grow in presence of oxygen are called aerobic while the others grow in absence of gaseous oxygen are called anaerobic. When organic matter undergoes fermentation (process of chemical change in organic matter brought about by living organisms) through anaerobic digestion, gas is generated. This gas is known as bio-gas. Biogas is generated through fermentation or bio-digestion of various wastes by a variety of anaerobic. and facultative-organisms. Facultative bacteria are capable of growing both in presence and absence of air or oxygen.

Aerobic and anaerobic fermentation canbe used to decompose organic matter. Normally aerobic fermentation produces CO_2, NH_3, and smallamounts of other gases along with a decomposed mass and evolution of heat. Anaerobic fermentation produces CO_2, CH_4, H2 and traces of other gases along with a decomposed mass. Aerobic fermentation is used when the main aim is to render the material hygenic and to recover the plant nutrients for reuse in the fields.The residue is rich in C, N_2,P, K and other nutrients. In a biogas plant the main aim is to generate methane andhence anaerobic digestion is used.Here the complex organic molecule is broken down into sugar, alcohols, pesticides and amino acids by acid producing bacteria. These products are then used to produce methane by another category of bacteria.

As already mentioned the treatment of any slurry or sludge containing a large amount of organic matter, utilizing bacteria and other micro-organisms under anaerobic conditions is commonly referred to as anaerobic digestion or simply digestion. This anaerobic digestion consists broadly of three phases:

(i) Enzymatic hydrolysis. Where the fats,starches and proteins contained in cellulosic biomass are broken down into simple compounds.

(ii) Acid formation. Where the micro organisms of facultative and anaerobic group collectively called as acid farmers, hydrolyse and ferment, are broken to simple compounds into acids and volatile solids. As a result complex organic compounds are broken down to short chemical simple organic acids. In some cases, these acids may be produced in such large quantities that the pH may be lowered to a level where all biological activity is arrested. This initial acid phase of digestion may last about two weeks and during this period a large amount of carbon dioxide is given off.

(iii) Methane formation. Where organic acids as formed above are then converted into methane (CH_4) and CO_2 by the bacteria which are strictly anaerobes. These bacteria are called methane fermenters, for efficient digestion these acid formers and methane fermenters must remains in a state of dynamic equilibrium. This equilibrium is .a very critical factor which decides the efficiency of generation. It has been demonstrated that the methane formers are sensitive to pH changes. A pH value between 6.5 to 8 is the best for fermentation and normal gas production. If organic acids are formed at a faster rate than the limited papulation of methane formers can assimilate, then the accumulated acids will reduce the pH to levels unfavorable to methane formers.

In controlled waste digestion the environment must be maintained suitable for the continued growth of both acid forming and methane-forming bacteria. The proper environment requires the balance between the population of organisms, food supply, temperature, pHand food accessibility. Digestion processes are being improved as the conditions which influence organic metabolism are better understood and better equipment and methods are available for controlling these conditions.

Basic processes and energetics

The general equation for anaerobic digestion is

$$C_xH_yO_z + (x-y/4-z/2)H_20 \text{ -------> } (x/2 - y/8 + z/4)\ CO_2 + (x/2 + y/8 - z/4)\ CH_4$$

For cellulose this becomes

$$(C_6H_{10}O_5)n + nH_2O \text{ ------> } 3n\ CO_2 + 3n\ CH_4$$

Some organic material (e.g. lignin) and all inorganic inclusions do not digest. These add to the bulk of the material, form a scum and can easily clog the system. In general 95% of the mass of the material is water. The reactions are slightly exothermic, with typical heats of reaction being about 1.5 MJ per kg dry digestible material, equal to about 250 kJ per mole of $C_6H_{10}O_5$. This is not sufficient to significantly affect the temperature of the bulk material.

If the input material had been dried and burnt, the heat of combustion would have been about 16 MJ/kg only 10% of the potential heat of combustion need be lost in the digestion process. This is 90% conversion efficiency. Moreover very wet input has been processed to give a highly convenient and controllable gaseous fuel, whereas drying of 95% aqueous input would have taken a further 40 MJ per kg of solid input. In practice digestion is seldom left to go to completion because of the long time involved, and 60% conversion is common. Gas yield is about 0.2 to 0.4 m^3 per kg dry digestible input at STP, with throughput of about 5 kg dry digestible solid per m^3 of liquid.

It is generally considered that three ranges of temperature favour particular types of bacteria. Digestion at higher temperature proceeds more rapidly than at lower temperature, with gas yield rates doubling at about every 5°C increase. The temperature ranges are (1) psicrophilic, about 20°C, (2) mesophilic, about 35°C and (3) thermophilic,about55°C. In tropical countries unheated digesters are likely to be at average ground temperature between 20 and 30°C. Consequently the digestion is psicrophilic, with retention times being at least 14 days. In colder climates the digesters have to be heated, probably by using part of the biogas output, and a temperature of about 35°C is likely to be chosen. Few digesters operate at 55°C unless the purpose is to digest material rather than produce excess biogas.

The biochemical processes occur in three stages, each facilitated by distinct sets of anaerobic bacteria.

1. Insoluble biodegradablematerials, e.g. cellulose, polysaccharides and fats, are broken down t:o soluble carbohydrates and fatty acids. This occurs in about a day at 25°C in an active digester.
2. Acid forming bacteria produce mainly acetic and propionic acid. This stage likewise takes about one day at 25°C.
3. Methane forming bacteria slowly, in about 14 days at 25°C, complete the digestion to - 70% CH_4, - 30% $C0_2$ with trace amounts of H_2 and perhaps H_2S. H_2 may play an essential role, and indeed some bacteria (e.g. clostridium) are distinctive in producing H_2 as the final product.

The methane forming bacteria are sensitive to pH, and conditions should be mildly acidic (pH 6.6 to 7.0) and certainly not below pH 6.2. Nitrogen should be present at 10% by mass of dry input, and phosphorus at 2%. A golden rule for successful digester operation is to maintain constant conditions of temperature and suitable input material. As a result a suitable population of bacteria is able to become established to suit these conditions.

When comparison of methane percentage from different organic matter was done for example cowdung. Poultry dropping and daily waste scum, then beat result was observed in dairy waste. 75 to 79 methane percentage found in dairy waste biogas while in cowdung, biogas was only 65 percent.

Advantages of anaerobic digestion

There are number of advantages of anaerobic digestion.

1. Calorific value of gas. One of the main benefits is the production of a byproduct the biogas which has a calorific value and can therefore, be used as an energy source to produce steam or hot water. Because in dairy industries energy source is very important for dairy use, so there is no problem of gas storage or supply, but gas can be directly useful in heat energy.
2. New sludge production. The conversion of organic matter to methane and carbon dioxide results in a smaller quantity of excess sludge.
3. Stable sludge. In the case of municipal digestion the main reason for their installation was to produce a non-putrescable and inoffensive sludge and in many cases only a proportion of the gas produced was utilised.
4. Low running cost. Then is no airation in the anaerobic treatment naturally in this digestion, running costs are a quarter of the equivalent aerobic system.
5. Low odour. Since the system is enclosed the. odours are contained. Compounds which are responsible forodour are broken down during digestion. The only slight odour of hydrogen sulphidenormally presents in gas. However if the gas is burnt the problem will not arise.
6. Stability. A well-adapted anaerobic sludge can be presented unfed for a considerable period of time without appreciable deterioration.
7. Pathogen reduction. Work has shown that passage of the effluent through the digester reduces the number pathogens present, so reducing subsequent disposal problems.
8. Value of sludge. The cases where aerobic sludgeis treated anaerobically the resultant sludge has a higher nitrogen content giving it increasing value as a fertilizer. It has also been reported that the sludge acts as a soil conditioner.
9. Low nutrient requirement. As a consequence of the low production of the bacterial solids the nutrient requirement is also low.

In addition using of biogas in industries will curtail the consumption of coal. Ifbiogas is used instead of coal in boilers, it will lessen the air pollution.

Factors Affecting Biodigestion or Generation of gas

The following are the factors that affect generation of biogas:

(1) pH or the hydrogen-ion concentration
(2) Temperature
(3) Total solid content of the feed material
(4) Loading rate
(5) Seeding
(6) Uniform feeding
(7) Diameter to depth ratio
(8) Carbon to Nitrogen ratio
(9) Nutrients
(10) Mixing or stirring or agitation of the content of the digester
(11) Retention time or rate of feeding
(12) Type of feed stocks
(13) Toxicity due end product
(14) Pressure
(15) Acid accumulation inside the digester.

1. pH or hydrogen ion concentration. pH of the slurry changes at various stages of the digestion.In the initialacid formation stage in the fermentation process, the pH is around 6 or less and much of $CO_2$is given off. In the latter 2-3 weeks' time, the pH increases as the volatile acid N_2 compounds are digested and CH_4 is produced. To maintain a constantsupply of a gas, it is necessary to maintain a suitable pH range in the digester.

The digester is usually buffered if the pH is maintained between 6.5 to 7.5. In this pH range, micro-organisms will be very active and bio digestion will be very efficient. If the pH range is between 4 and 6 it is called acidic. If it is between 9 and 10 it is called alkaline. Both these are detrimental to the methanogenic (Methane production) organisms. It should always be remembered that there should not be any sudden upset in the pH by the addition of any material which is likely to cause an imbalance in the bacterial population.

The ideal pH valves for digestion of sewage solids are reported to be in the range 7 to 7 .5. But a slightly higher value of 8.2 has been reported to be optimum for digestion of raw animal or plant wastes.

2. Temperature. Methane bacteria work best at a temperature of between 35° -38°C. The fall in gas production starts at 20°Cand stops at a temperature of l0°C. At one experiment 2.25 cum of gas was produced from 4.25 m^3 of cattle dung everyday when the digester temperature was 25°C. When the temperature was raised to 28.3°C,the gas production increased by 50% to 3.75 cum/day.

There are two significant temperature zones in anaerobic digestion. These have been studied in some detail for digestion of sewage sludges for 90% digestion. Fig. (7.5.1) shows the time required for 90% digestion at various temperatures, and the two temperature zones. It has been established that two types of microorganisms, mesophilic and thermophilic are responsible ,for digestion at the two temperature ranges. The optimum mesophilic temperature lies at about 35°C, while the optimum thermophilic temperature is around 55°C. In temperature climates most of the average digestion tanks are heated to 35°C SQ as to reduce the time required for digestion and therefore the capacity of the tanks. The thermophilic range has not been put to usebecause of the problems associated with heating the tanks to such high temperatures. Heating of tanks designed mainly for collection of biogas may not be practicable, but it must be understood that temperature ill a very important factor since it affects the bacterial activity directly. Any gross deviation from a normal operating temperature may result in the unsatisfactory performance of the digester.

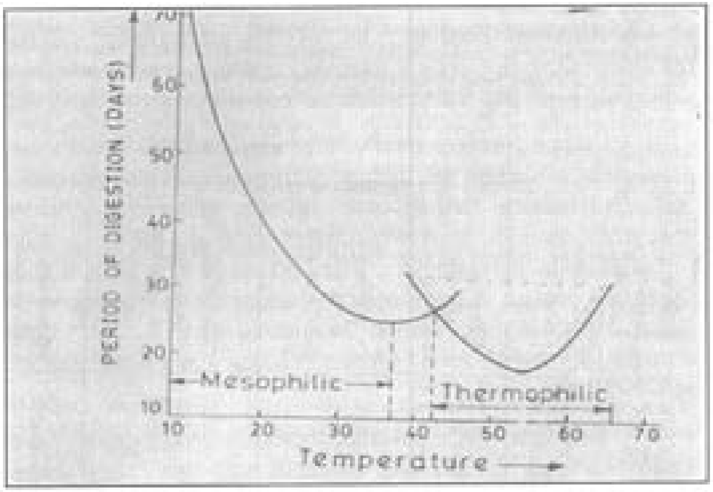

Fig. 1.1 Effect of temperature on digestion

The gas production starts falling very steeply when the temperature goes below 20°C and almost stops at 10°C. Generally it is easier to maintain the temperature of the digester at the mesophilic range rather than the thermophilic range.

In addition to ambient temperature, other weather conditions also influence the gas generation viz.

(a) Wind velocity (chill factor)

(b) Sun shine directly available to keep the dome at the optimum temperature

(c) Type offood given to cattle (in case ofGobar gas generation).

3. Total Solid Content. The cow dung is mixed usually in the proportion of 1: 1 (by weight) in order to brins the total solid content to 8-10%. The raw cowdung contains 80-82% of moisture. The balance 18-20% is termed as total solids. The adjustment of total solid content helps in bidegesting the material at the faster rate, and also in deciding the mixing,of the various crop residues weeds plants etc, as feed stocks in biogasdigester.·

4. Loading Rate. Loading rate is defined as the amount of raw material(usually kg of volatile solids) fed to the digester per day per unitvolume. Most municipal sewage treatment plants operate at a loading rate of 0.5 t.o 1.6 kg of volatile soilds per m^3 per day. Much higher rates are possible,but as with most aspects of digesters, the optimur.ısituation is a compromise. If a digester is loaded with too much raw material at a time, acids will accumulate and fermentation will stop. The main advantage of higher loading rate is that by stufting a lot into a 1ittle space, the size and therefore the cost of the digester can be reduced. The results of a particular investigation for the loading range 1.2 to 5.3 kgvolatile solids/m^3/day are given in the Table

Table 1 : Effect of Dung Loading on Gas production

Expt. No.	1	2	3	4
Dung Loading, kg/m^3/day	8.0	16.0	24.0	32.0
Vol. Solids loading, kg/m^3/day	1.17	2.40	3.76	5.29
Detention time, day	50.0	25.0	17.0	12.0
Gas production / unit vol. of digester, m^3/day	0.022	0.42	0.52	0.47
Gas production / unit / vol. of matter added, m^3/ m^3	0.20	0.16	0.14	0.09
% Reduction in volatile matter	22.8	19.5	14.3	14.2

5. Seeding. Although the bacteria required for acid fermentation and methane feremationare present in the cowdung, their numbers are not large. While the acid formers proliferate fast and increase in numbers, the methane formers reproduce and multiply slowly. It would be advantageous to increase the number of methane formers by artificial seeding with a digested sludge that is rich in methane formers. But beyond a certain seed concentration, the gas production will decrease, due to reduction of raw cow dung solids fedto the digester.

6. Uniform Feeding. One of the prerequisites of good digestion is the uniformfeedingofthe digester so that the microorganisms arekeptin a relatively constant organic solids concentration at all times. Therefore the digester must be fed at the same time everyday with a balanced feed of the same quality and quantity.

7. Carbon Nitrogen ratio of the input material. Besides carbon the quantity of N_2present in the wasteis a crucial factor in the production ofbiogas. All livingorganisms requirenitrogen toform their cellproteins from a biological view point, a digesterisa culture of bacteria feeding upon and converting organic wastes.The elements of carbon (in the form of carbon hydrates) and nitrogen(as protein, ammonia nitrates, etc.) are the main food of anaerobic bacteria. Carbon is used for energy and nitrogen forbuilding the cell structure. The bacteria use up carbon about 30 times faster than they useup nitrogen. Carbonand nitrogen should be present in the proper proportion.Other conditions (temp., pH etc) beingfavourable, a carbon, nitrogen (C/N) ratio of 30(i.e. 30 times more carbon than nitrogen) will permit digestion to proceed at the optimum rate. When there is too much nitrogen, the carbon soon becomes exhausted and fermentation stops. Nitrogen ratio that best suits for maximum microbiological activity is 30:1.

8. Diameter to DepthRatio. Research investigations reveal that gas production perunit volume of digester capacity was maximum when the diameter to depth ratio was in the range of0.66 to 1.00. But reports from the field do not confirm this. Digesters of 16 ft depth aad.4 t.o 5 ftdiameter were reported to be working satisfactory. Onereason may be that because in a simple unstirred single stage digester the temperature variesatdifferent depths. The most actively digesting sludge is in the lower half of the digester and this is less affected by changes in night andday temperature.

9. Nutrients. The major nutrients required by the bacteria in the digester are C, H_2, O_2, P and S, of these nutrients N_2 and P are always in short supply and therefore to maintain proper balance of nutrients an extra raw material rich in phosphrous (night soil) and N_2(chopped leguminous plants) should be added along with the cow dung to obtain maximum production of gas.

10. Mixing or stirring or agitation of the content of the digester. Since bacteria in the digester have very limited reach to their food, it is necessary that the slurry is properly mixed and bacteria get their food supply. It is found that slight mixing improves the fermentation; however a violent slurry agitation retards the digestion.

In sewage treatment plants, the digesters, especially the first tank in two stage digestion, are equipped for mixing the tank contents either by sludge recirculation pumps, or gas recirculation or by using one or more deep draft tubes with propeller mixers at the bottom. But all these methods are costly to adopt, especially in the small plants that are constructed for digesting the individual house hold and farmyard waste. However some amount of mixing is required if the digester is to operate efficiently. This can be achieved to some extent by designing the inlet and outlet arrangements in a proper manner so that incoming slurryin the tank the slurry tends to stir up the contents of the digester. If there is little or no mixing in the tank, the slurry in the tank will stratify into three distinct zones-scum at the top, digested sludge lying at the bottom (the actively digesting sludge lying on top of well digested sludge) and a thin liquid called supernatant between. Methane organisms in cultures are reported to developin the sedimentat the bottom and scarcely in the upper layers ofthe medium. But the scum at the top is rich in the volatile acids. Mixing brings the methane bacteria from the bottom of the digester into contact with the volatile acids so that further stabilization can proceed efficiently and methane production speeded.

11 Retention time or rate of feeding. The period of retention of the material for biogas generation, inside the digester is known as the retention period. This period will depend on the type of feed stocks and the temperature. Normal value of the retention period is between 30 and 45 days and in some cases 60 days.

By regulating the daily feed volume, the retention time can becontrolled.

Periods for different materials to get well fermentation are:

(i) Cow and buffalo dung - 50 days
(ii) Pig-dung- 20 days
(iii) Poultry droppings -20 days
(iv) Night soil-30 days

As mentioned this period also depends on the ambient temperature, in tropical regions it can be even 30 days. Actually in India, 30, 40 and 50 days, retention is adopted depending on the region.

The retention period of a digester is calculated by dividing total capacity of the digester by the rate at which organic matter is fed into it methanogenic bacteria multiply at the slower rate. Methane organisms become double in 2-4 days or even in more days. Retention time should not be less than 2-4 days, otherwise bacteria may come out with the slurry affecting the whole process of biogas production. Hence in continuous type of plant the rate of feeding is an important factor. Maximum gas production is achieved by daily uniform feeding. The rate

12. Type of feed stocks. As already stated, all plant and animal wastes may be used as the feed materials for a digester.

13. Toxicity. The digested slurry, if allowed to remain in the digester beyond a certain time, becomes toxic to the micro organisms and might cause fall in the fermentation rate.

14.Pressure. Some work conducted at National Environmental, Engineering Research Institute (NEERI) Nagpur and other places indicated that the pressure on the surface of slurry also affects the fermentation.

15. Acid accumulation inside the digester. Intermediate products such as acetic propionic butyric acids are produced, during the process of bio digestion. This causes in a decrease of the pH, especially when fresh feed material is added in large amount.

2. Classification of Biogas Plants

1. Continuous and batch types

(a) Continuous plant.

There is a single digester in which raw material are charged regularly and the process goes on without interruption except for repair and cleaning etc. In this case the raw material is self buffered (like cow dung) or otherwise thoroughly mixed with the digesting mass where dilution prevents souring and the biogas production is maintained. The continuous process may be completed in a single stage or separated into two stages.

I) Single stage process.

The entire process of conversion ofcomplex organic compounds into biogas in completed in a single chamber. This chamber is regularly fed with the raw materials while thespent residue keeps moving out. Serious problems are encountered withagricultural residues when fermented in a single continuous process.

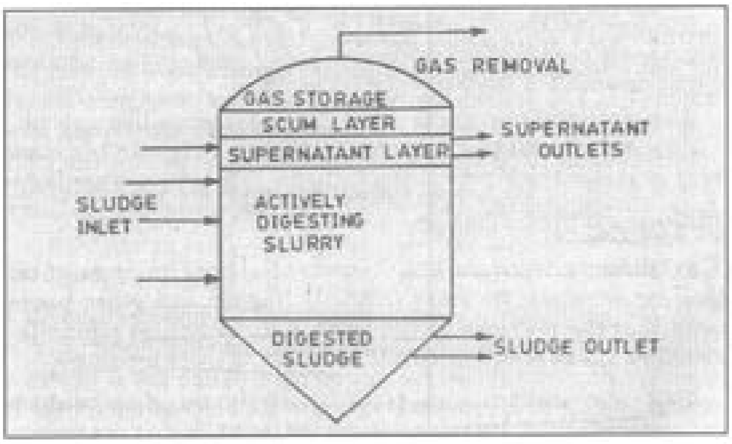

Fig. 1.2 : Schematic of single process conventional digester

II) Double stage process.

The acidogenic stage and methanogenic stage are physically separated into two chambers. Thus the first stage of acid production is carried out in a separate chamber and only the diluted acids are fed into the second chamber where bio-methanation takes place and the biogas can be collected from the second chamber.

Refer Fig. 7.6.2. Considering the problems encountered in fermenting fibrous plant waste materials the two stage process may offer higher potential of success. However, appropriate technology suiting to rural gas

India is needed to be developed based on the double stage process.

The main features of continuous plant are that:

(1) It will produce gas continuously;

(2) It requires small digestion chambers.

(3) It needs lesser period for digestion;

(4) It has less problems compared to batch type and it is easier in operation.

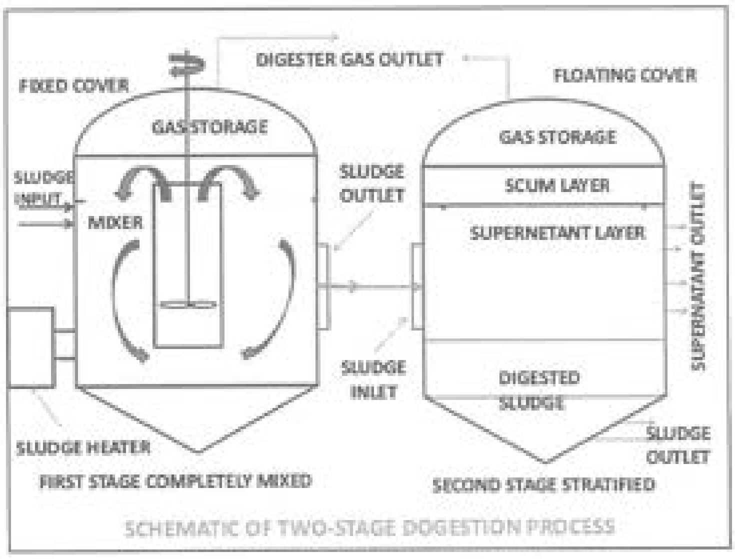

Fig. 1.3 : Schematic of two-stage digestion process

b) The batch Plant.

The feeding is between intervals, the plant is emptied once the process of digestion is complete. In this type, a battery of digesters are charged along with lime, urea etc. and allowed to produce gas for 40-50 days. These are charged and emptied one by one in a synchronous manner which maintains a regular supply of the gas through a common gas holder. Sometimes the freshly charged digester is aerated for a few days after which it is closed to atmosphere. The biogas supply may be utilised after 8-10 days. Obviously such a plant would be expensive to install and unless operated on large scale it would not be economical. Such systems have been generally installed in European countries. Their installation and operation being capital and labour intensive. They are totally unsuitable for Indian conditions, except when it is taken as a commercial venure.

The main features of the batch plant are:

i) The gas production in it, is intermittent, depending upon the clearing of the digester.

ii) It needs several digesters or chambers for continuous gas production, these are fed alternately.

iii) Batch plants are good for long fibrous materials.

iv) This plant needs addition of fermented slurry to start the digestion process.

2. The dome and the drum types

There are numerous models of a biogas plant mainly two main types are usually used:

i) The floating gas holder plant and ii) Fixed dome digester.

KVIC type biogas plant

This mainly consists of a digester or pit for fermentation and a floating drum for the collection of gas. Digester is 3.5-6.5 m in depth and 1.2 to 1.6 m in diameter. There is a partition wall in the center, which divides the digester vertically and submerges in the slurry when it is full. The digester is connected to the inlet and outlet by two pipes. Through the inlet, the dung is mixed with water (4:5) and loaded into the digester. The fermented material will flow out through outlet pipe. The outlet is generally connected to a compost pit. The gas generation takes place slowly and in two stages. In the first stage, the complex, organic substances contained in the waste are acted upon by a certain kind of bacteria, called acid formers and broken up into small-chain simple acids. In the second stage, these acids are acted upon by another kind of bacteria, called methane formers and produce methane and carbon dioxide.

Gas holder

The gas holder is a drum constructed of mild steel sheets. This is cylindrical in shape with concave. The top is supported radically with angular iron. The holder fits into the digester like a stopper. It sinks into the slurry due to its own weight and rests upon the ring constructed for this purpose. When gas is generated the holder rises and floats freely on the surface of slurry. A central guide pipe is provided to prevent the holder from tilting. The holder also acts as a seal for the gas. The gas pressure varies between 7 and 9 cm of water column. Under shallow water table conditions, the adopted diameter of digester is more and depth is reduced. The cost of drum is about 40% of total cost of plant. It requires periodical maintenance. The unit cost of KVIC model with a capacity of 2 m3/day costs approximately Rs.14, 000 - 00.

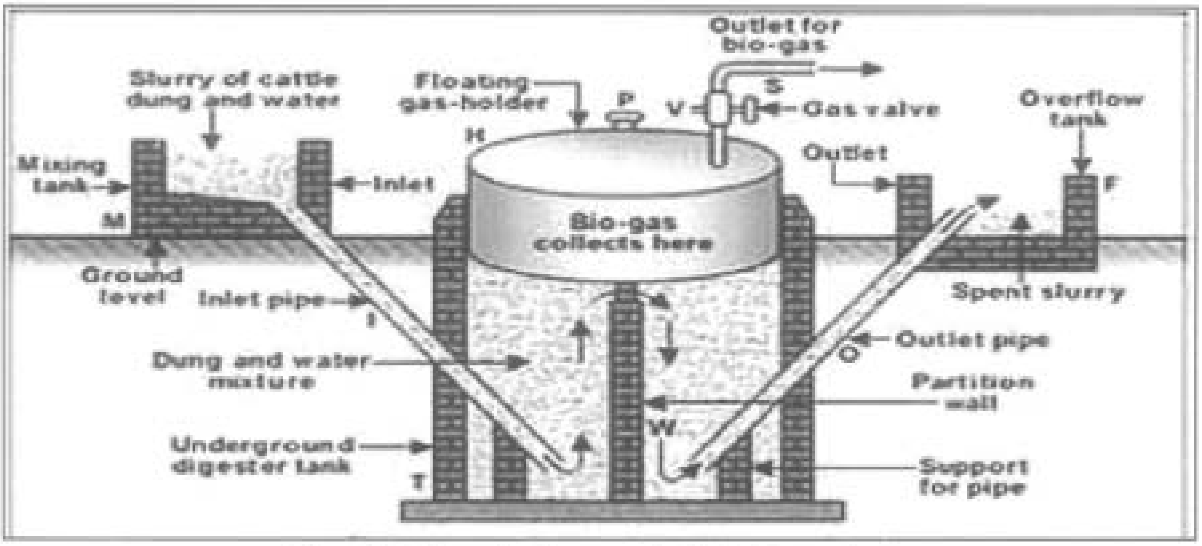

Fig. 1.4 : Schematic diagram of a KVIC biogas plant.

Janata biogas plant

The design of this plant is of Chinese origin but it has been introduced under the name "Janata biogas plant" by Gobar Gas Research Station, Ajitmal in view of its reduced cost. This is a plantwhere no steel is used, there is no moving part in it and maintenance cost is low. The plant can be constructed by village mason taking some pre-explained precautions and using all the indigenously available building materials. Good quality of bricks and cement should be used to avoid the afterward structural problems like cracking of the dome and leakage of gas. This model have a higher capacity when compared with KVIC model, hence it can be used as a community biogas plant. This design has longer life than KVIC models. Substrates other than cattle dung such as municipal waste and plant residues can also be used in janata type plants. The plant consists of an underground well sort of digester made of bricks and cement having a dome shaped roof which remains below the ground level is shown in figure. At almost middle of the digester, there are two rectangular openings facing each other and coming up to a little above the ground level, act as an inlet and outlet of the plant. Dome shaped roof is fitted with a pipe at its top which is the gas outlet of the plant. The principle of gas production is same as that of KVIC model. The biogas is collected in the restricted space of the fixed dome, hence the pressure of gas is much higher, which is around 90 cm of water column.

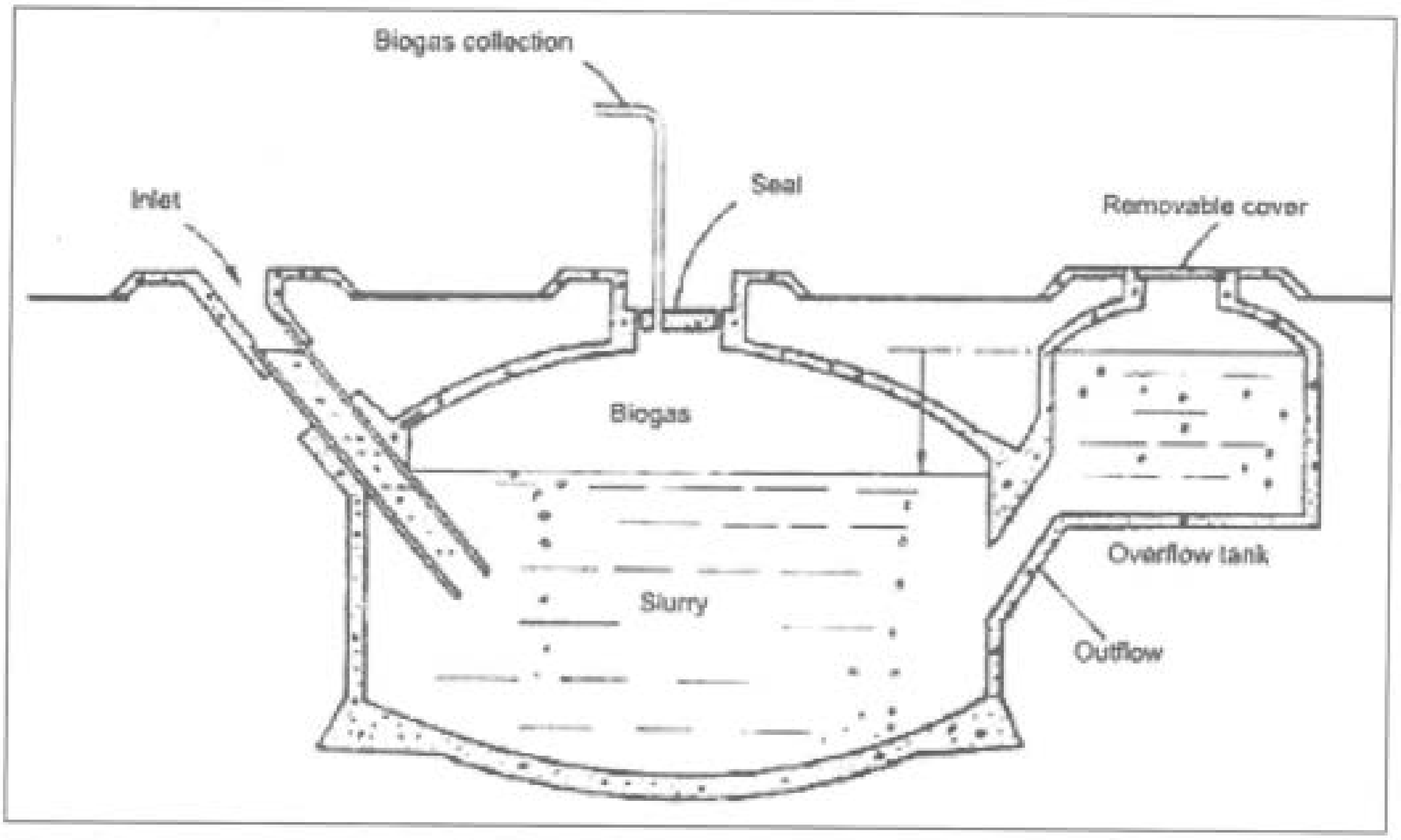

Fig. 1.5 : Janata biogas plant

Deenbandhu biogas plant

Deenbandhu model was developed in 1984, by Action for Food Production (AFPRO), a voluntary organization based in New Delhi. Schematic diagram of a Deenabandhu biogas plant entire biogas programme of India as it reduced the cost of the plant half of that of KVIC model and brought biogas technology within the reach of even the poorer sections of the population. The cost reduction has been achieved by minimizing the surface area through joining the segments of two spheres of different diameters at their bases. The cost of a Deenbandhu plant having a capacity of 2 m^3/day is about Rs.8000. The Deenbandhu biogas plant has a hemispherical fixed-dome type of gas holder, unlike the floating dome of the KVIC-design is shown. The dome is made from pre-fabricated ferrocement or reinforced concrete and attached to the digester, which has a curved bottom. The slurry is fed from a mixing tank through an inlet pipe connected to the digester. After fermentation, the biogas collects in the space under the dome. It is taken out for use through a pipe connected to the top of the dome, while the sludge, which is a by-product, comes out through an opening in the side of the digester. About 90 percent of the biogas plants in India are of the Deenbandhu type.

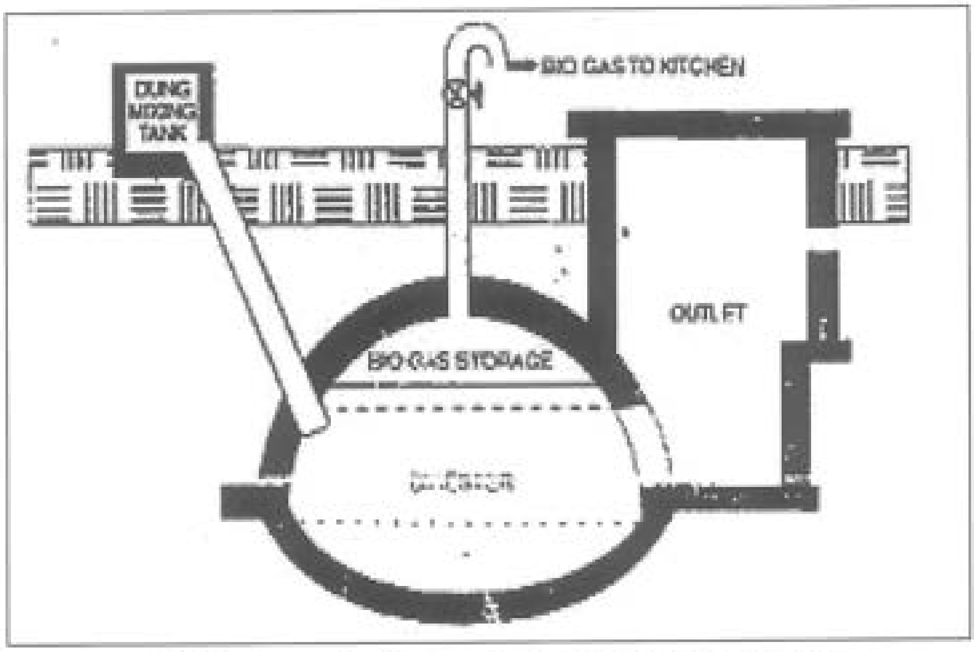

Fig. 1.6 : Schematic diagram of a Deenabandhu biogas plant

Different types of biogas plants

- the floating-drum plant with a cylindrical digester (KVIC model),
- the fixed-dome plant with a brick reinforced, moulded dome (Janata model)
- the floating-drum plant with a hemisphere digester (Pragati model)
- the fixed-dome plant with a hemisphere digester (Deenbandhu model)
- the floating-drum plant made of angular steel and plastic foil (Ganesh model)
- the floating-drum plant made of pre-fabricated reinforced concrete compound units
- the floating-drum plant made of fibre-glass reinforced polyester.

Small Scale Biogas Digester

Fixed-dome Plants

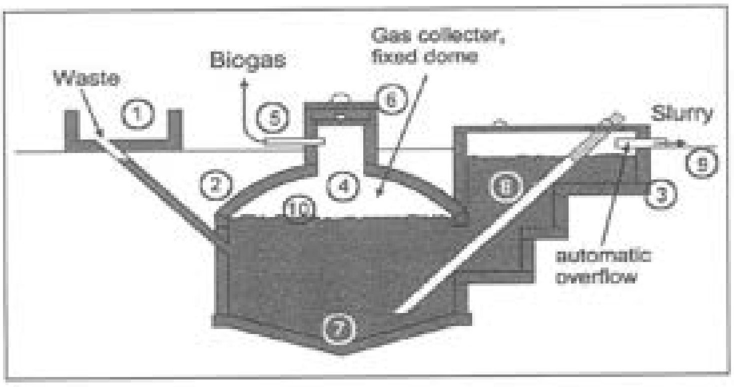

Fig. 1.7 : Fixed dome plant

A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level inthe digester and the slurry level in the compensation tank. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. There are also no rusting steel parts and hence a long life of the plant (20 years or more) can be expected. The plant is constructed underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes. The construction of fixed dome plants is labor-intensive, thus creating local employment. Fixed-dome plants are not easy to build. They should only be built where construction can be supervised byexperienced biogas technicians. Otherwise plants may not be gas-tight (porosity and cracks). The basic elements of a fixed dome plant (here the Nicarao Design) are shown in the figure.

Nicarao design:

1. Mixing tank with inlet pipe and sand trap. 2. Digester. 3. Compensation and removal tank. 4. Gasholder. 5. Gaspipe. 6. Entry hatch, with gastight seal. 7. Accumulation of thick sludge. 8. Outlet pipe. 9. Reference level. 10. Supernatant scum, broken up by varying level.

Function - A fixed-dome plant comprises of a closed, dome-shaped digester with an immovable, rigidgas-holder and a displacement pit, also named 'compensation tank'. The gas is stored in the upper part of the digester. When gas production commences, the slurry is displaced into the compensating tank. Gas pressure increases with the volume of gas stored, i.e. with the height difference between the two slurry levels. If there is little gas in the gas-holder, the gas pressure is low.

Digester - The digesters of fixed-dome plants are usually masonry structures, structures of cement and ferro-cementexist. Main parameters for the choice of material are:

- Technical suitability (stability, gas- and liquid tightness);
- cost-effectiveness;
- availability in the region and transport costs;
- availability of local skills for working with the particular building material.

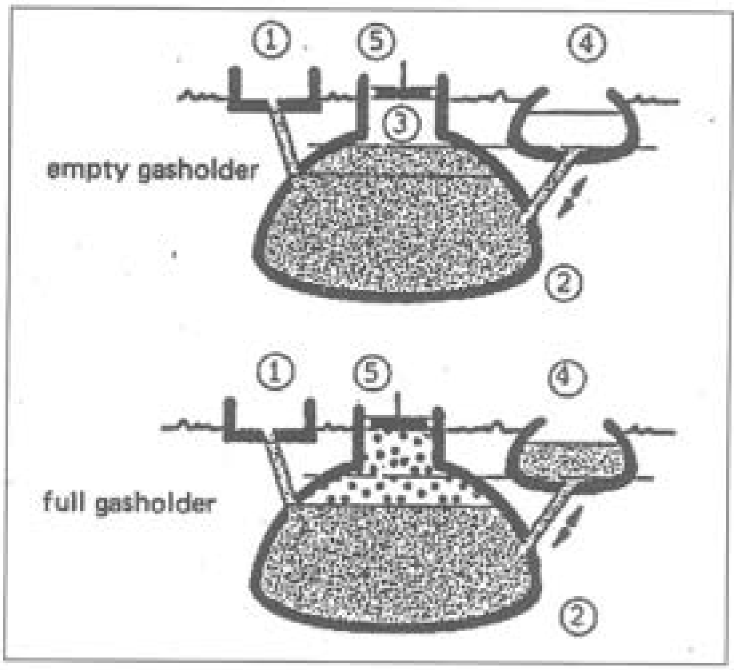

Fig. 1.8 : Basic function of a fixed-dome biogas plant, 1 Mixing pit, 2 Digester, 3 Gasholder, 4 Displacement pit, 5 Gas pipe

Fixed dome plants produce just as much gas as floating-drum plants, *if they are gas-tight*. However, utilization of the gas is less effective as the gas pressure fluctuates substantially. Burners and other simple appliances cannot be set in an optimal way. If the gas is required at constant pressure (e.g., for engines), a gas pressure regulator or a floating gas-holder is necessary.

Gas Holder - The top part of a fixed-dome plant (the gas space) must be gas-tight. Concrete, masonry and cement rendering are not gas-tight. The gas space must therefore be painted with a gas-tight layer (e.g. 'Water-proofer', Latex or synthetic paints). A possibility to reduce the risk of cracking of the gas-holder consists in the construction of a weak-ring in the masonry of the digester. This "ring" is a flexible joint between the lower (water-proof) and the upper (gas-proof) part of the hemispherical structure. It prevents cracks that develop due to the hydrostatic pressure in the lower parts to move into the upper parts of the gas-holder.

Types of Fixed Dome Plants

- Chinese fixed-dome plant is the archetype of all fixed dome plants. Several million have beenconstructed in China. The digester consists of a cylinder with round bottom and top.
- Janata model was the first fixed-dome design in India, as a response to the Chinese fixed domeplant. It is not constructed anymore. The mode of construction lead to cracks in the gasholder -very few of this plant had been gas-tight.
- Deenbandhu, the successor of the Janata plant in India, with improved design, was more crackproofand consumed less building material than the Janata plant. with a hemisphere digester
- CAMARTEC model has a simplified structure of a hemispherical dome shell based on a rigidfoundation ring only and a calculated joint of fraction, the so-called weak / strong ring. It wasdeveloped in the late 80s in Tanzania.

Climate and Size - Fixed-dome plants must be covered with earth up to the top of the gas-filled spaceto counteract the internal pressure (up to 0,15 bar). The earth cover insulation and the option for internal heating make them suitable for colder climates. Due to economic parameters, the recommended minimum size of a fixed-dome plant is 5 m3. Digester volumes up to 200 $m^3$are known and possible.

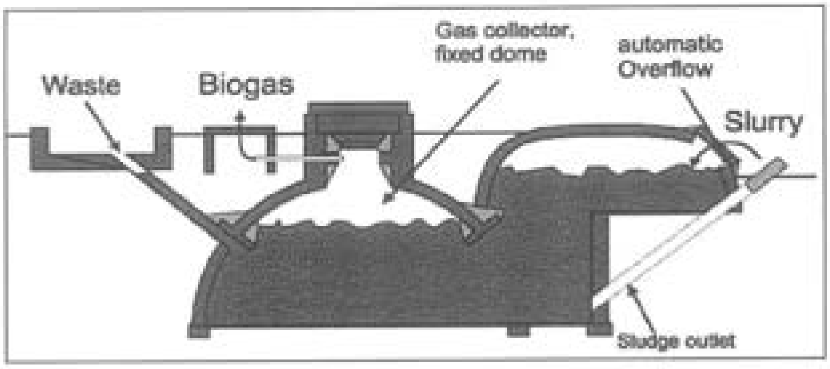

Fig. 1.9 : CAMARTEC model

Advantages: Low initial costs and long useful life-span; no moving or rusting parts involved; basic design is compact, saves space and is well insulated; construction creates local employment. Advantages are the relatively low construction costs, the absence of moving parts and rusting steel parts. If well constructed, fixed dome plants have a long life span. The underground construction saves space and protects the digester from temperature changes. The construction provides opportunities for skilled local employment.

Disadvantages: Masonry gas-holders require special sealants and high technical skills for gas-tight construction; gas leaks occur quite frequently; fluctuating gas pressure complicates gas utilization; amount of gas produced is not immediately visible, plant operation not readily understandable; fixed dome plants need exact planning o: levels; excavation can be difficult and expensive in bedrock. Disadvantages are mainly the frequent problems with the gas-tightness of the brickwork gas holder (a small crack in the upper brickwork can cause heavy losses of biogas). Fixed-dome plants are, therefore, recommended only where construction can be supervised by experienced biogas technicians. The gas pressure fluctuates substantially depending on the volume of the stored gas. Even though the underground construction buffers temperature extremes, digester temperatures are generally low. Fixed dome plants can be recommended only where construction can be supervised by experienced biogas technicians.

Variations: Some companies are now looking into small pre-fab fixed dome plants made of fibreglass which appears to be a low cost alternative to construction intensive masoned plants. A custom made plant can be produced in 2 days and -after transport-installed in less than 1 day.

Floating Drum Plants

Floating-drum plants consist of an underground digester and a moving gas-holder. The gas-holder floats either directly on the fermentation slurry or in a water jacket of its own. The gas is collected in the gas drum, which rises or moves down, according to the amount of gas stored. The gas drum is prevented from tilting by a guiding frame. If the drum floats in a water jacket, it cannot get stuck, even in substrate with high solid content.

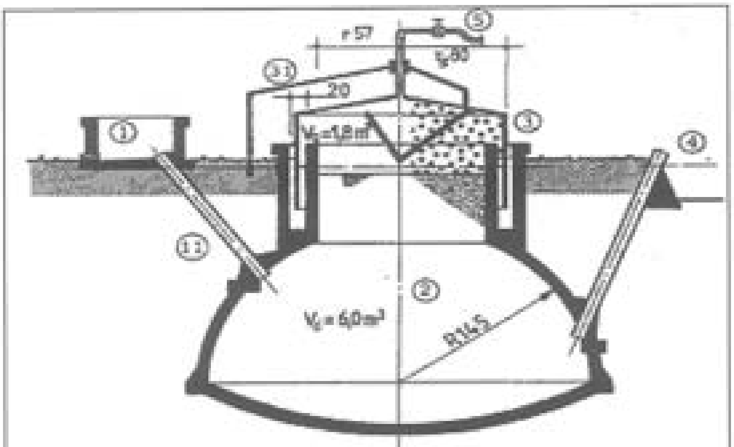

Fig. 1.10 : Floating drum biogas plant

Drum - In the past, floating-drum plants were mainly built in India. A floating-drum plant consists ofa cylindrical or dome-shaped digester and a moving, floating gas-holder, or drum. The gas-holder floats either directly in the fermenting slurry or in a separate water jacket. The drum in which the biogascollects has an internal and/or external guide frame that provides stability and keeps the drum upright. If biogas is produced, the drum moves up, if gas is consumed, the gas-holder sinks back.

Size - Floating-drum plants are used chiefly for digesting animal and human feces on a continuous feed mode of operation, i.e. with daily input. They are used most frequently by small- to middle-sized farms (digester size: 5-15m3) or in institutions and larger agro-industrial estates (digester size: 20- 100m3).

Disadvantages: The steel drum is relatively expensive and maintenance-intensive. Removing rust and painting has to be carried out regularly. The life-time of the drum is short (up to 15 years; in tropical coastal regions about five years). If fibrous substrates are used, the gas-holder shows a tendency to get "stuck" in the resultant floating scum.

Water Jacket Floating Drum Plant

Water-jacket plants are universally applicable and easy to maintain. The drum cannot get stuck in a scum layer, even if the substrate has ahigh solids content. Water-jacket plants are characterized by a long useful life and a more aesthetic appearance (no dirty gas-holder). Due to their superior sealing of the substrate (hygiene!), they are recommended for use in the fermentation of night soil. The extra cost of the masonry water jacket is relatively modest.

Material of Digester and Drum

The digester is usually made of brick, concrete or quarry-stone masonry with plaster. The gas drum normally consists of 2.5 mm steel sheets for the sides and 2 mm sheets for the top. It has welded-inbraces which break up surface scum when the drum rotates. The drum must be protected againstcorrosion. Suitable coating products are oil paints, synthetic paints and bitumen paints. Correct priming is important. There must be at least two preliminary coats and one topcoat. Coatings of used oil are cheap. They must be renewed monthly. Plastic sheeting stuck to bitumen sealant has not given good results. In coastal regions, repainting is necessary at least once a year, and in dry uplands at least every other year. Gas production will be higher if the drum is painted black or red rather than blue or white, because the digester temperature is increased by solar radiation. Gas drums made of 2 cm wire mesh- reinforced concrete or fiber-cement must receive a gas-tight internal coating. The gas drum should have a slightly sloping roof, otherwise rainwater will be trapped on it, leading to rust damage. An excessively steep-pitched roof is unnecessarily expensive and the gas in the tip cannot be used because when the drum is resting on the bottom, the gas is no longer under pressure. Floating-drums made of glass-fiber reinforced plastic and high-density polyethylene have been used successfully, but the construction costs are higher compared to using steel. Floating-drums made of wire-mesh-reinforced concrete are liable to hairline cracking and are intrinsically porous. They require a gas-tight, elastic internal coating. PVC drums are unsuitable because they are not resistant to UV

Guide Frame

The side wall of the gas drum should be just as high as the wall above the support ledge. The floating drum must not touch the outer walls. It must not tilt, otherwise the coating will be damaged or it will get stuck. For this reason, a floating-drum always requires a guide. This guide frame must be designed in a way that allows the gas drum to be removed for repair. The drum can only be removed if air can flow into it, either by opening the gas outlet or by emptying the water jacket. The floating gas drum can be replaced by a balloon above the digester. This reduces construction costs but in practice problems always arise with the attachment of the balloon to the digester and with the high susceptibility to physical damage.

Types of Floating Drum Plants

- KVIC model with a cylindrical digester, the oldest and most widespread floating
- drum biogas plant from India.
- Pragati model with a hemisphere digester
- Ganesh model made of angular steel and plastic foil
- floating-drum plant made of pre-fabricated reinforced concrete compound units
- floating-drum plant made of fibre-glass reinforced polyester
- low cost floating-drum plants made of plastic water containers or fiberglass drums: ARTI Biogasplants

BORDA model: The BORDA-plant combines the static advantages of hemispherical digesterwith the process-stability of the floating-drum and the longer life span of a water jacket plant.

Advantages: Advantages are the simple, easily understood operation - the volume of stored gas isdirectly visible. The gas pressure is constant, determined by the weight of the gas holder. Theconstruction is relatively easy, construction mistakes do not lead to major problems in operation andgas yield.

Disadvantages: Disadvantages are high material costs of the steel drum, the susceptibility of steelparts to corrosion. Because of this, floating drum plants have a shorter life span than fixed-domeplants and regular maintenance costs for the painting of the drum.

Low Cost Polyethylene Tube Digester

Digester - In the case of the Low-Cost Polyethylene Tube Digester model which is applied in Bolivia (Peru, Ecuador, Colombia, Centro America and Mexico), the tubular polyethylene film (two coats of 300 microns) is bended at each end around a 6 inch PVC drainpipe and is wound with rubber strap of recycled tire-tubes. With this system a hermetic isolated tank is obtained.

One of the 6" PVC drainpipes serves as inlet and the other one as the outlet of the slurry. In the tubedigester finally, a hydraulic level is set up by itself, so that as much quantity of added prime matter(the mix of dung and water) as quantity of fertilizer leave by the outlet.Because the tubular polyethylene is flexible, it is necessary to construct a "cradle" which willaccommodate the reaction tank, so that a trench is excavated.

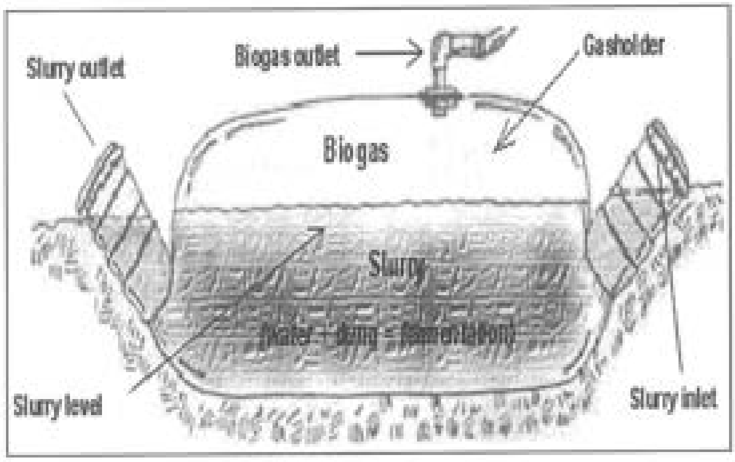

Fig. 1.11 : Low cost polyethylene tube digester

Gas Holder and Gas Storage Reservoir - The capacity of the gasholder corresponds to 1/4 of the totalcapacity of the reaction tube. To overcome the problem of low gas flow rates, two 200 micronstubular polyethylene reservoirs are installed close to the kitchen, which gives a 1.3 m^3 additional gasstorage.

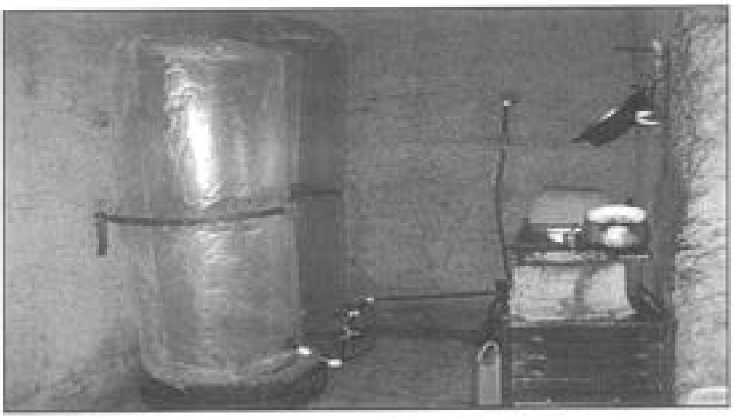

Fig. 1.12 : Gas Holder and Gas Storage Reservoir

Baloon Plants - A balloon plant consists of a heat-sealed plastic or rubber bag (balloon),combining digester and gas-holder. The gas is stored in the upper part of the balloon. The inlet andoutlet are attached directly to the skin of the balloon. Gas pressure can be increased by placingweights on the balloon. If the gas pressure exceeds a limit that the balloon can withstand, it maydamage the skin. Therefore, safety valves are required. If higher gas pressures are needed, a gas pumpisrequired. Since the material has to be weather- and UV resistant, specially stabilized, reinforcedplastic or synthetic caoutchouc is given preference. Other materials which have been usedsuccessfully include RMP (red mud plastic), Trevira and butyl. The useful life-span does usually notexceed 2-5 years.

Advantages: Standardized prefabrication at low cost, low construction sophistication, ease oftransportation, shallow installation suitable for use in areas with a high groundwater table; highdigester temperatures in warm climates; uncomplicated cleaning, emptying and maintenance; difficultsubstrates like water hyacinths can be used.Balloon biogas plants are recommended, if local repair is or can be made possible and the costadvantage is substantial.

Disadvantages: Low gas pressure may require gas pumps; scum cannot be removed during operation;the plastic balloon has a relatively short useful life-span and is susceptible to mechanical damage andusually not available locally. In addition, local craftsmen are rarely in a position to repair a damagedballoon. There is only little scope for the creation of local employment and, therefore, limited self-helppotential.

Materials Used for Bio-gas Generation

Feed stock materials. The following organic matter rich feed stocks are found feasible for their use as input materials for biogas production.

Animal wastes: Cattle dung, urine, goat and poultry droppings, slaughter house wastes, fishwastes, foetus wastes, leather and wood wastes, sericulture wastes elephant dung, piggery wastes etc.

Human wastes: Faeces, urine and other wastes emanating from human occupations.

Agricultural wastes: Aquatic and terrestrial weeds crop residue, stubbles of crops, sugarcane trash, spoiled fodder, bagasse, tobacco wastes oilcakes fruit and vegetable processing wastes, press mud, cotton and textile wastes, spent coffee and tea wastes.

Waste of aquatic origin: Marine plants, twigs, algae, water hyacinth and water weeds:

Industrial wastes : Sugar factory, tannery, paper etc.

The following three marine plants (waste of aquatic origin) are considered promising for biomass production.

(i) Water hyacinth (ii) Algae and (iii) Ocean kelp.

(i) Water hyacinth. It is a floating water plant which grows mamly in the rivers and canals of the world. Water hyacinth otherwise botanically called a. "EichhoniaGassipes" is one of the important sources for biogas production next to animal waste. Water hyacinth removes both nutrients and organic directly from water via their expensive root system, which can increase at their phenomental rate of 15 per cent of their surface area per day, producing at least 20 tonnes net weight per hectare per day. Based on measured growth rates it is estimated that one hectare of water hyacinth could remove the nitrogen and phosphorus wastes of over 800 people per day. These concentrated nutrients can then be removed from the system by harvesting water hyacinth thereby achieving a dual goal of purifying the water and giving nutrients to the microbes for digestion for producing biogas.

Water hyacinth contains 95 per cent of water and only about 5 per cent of cellulose, lignin etc. Its growth is enhanced more in tropical weather and is ideal to grow in India. It grows extremely well in sewage ponds thereby cleaning the ponds. It sucks water so much, water would become scarce soon if not supplemented. Water hyacinth gives out 350 to 420 litres of biogas per kg of dry weight. It absorbs salts of copper, lead, silver cadmium and chromium. The biogas produced out of water hyacinth is slightly higher in methane content. Once it is planted in any water, it is extremely difficult to wipe out it traces. Besides being good food, fertilizer and biogas producer, its excellent for paper production.

(ii) Algae. Algae are single cell plants grow in profusion in lakes, tanks etc. There are several varieties of algae. Some are considered excellent food material since they have very high protein contein (upto 50 per cent). Algae occur in the seas also but these species are not considered for biomass production since their yield rates are poor. Among fresh water algae, four varieties have high yields ; chlorella, scenedesmus, ulothoria and spirutina. The best way of growing them would be in shallow inland ponds. Algae can be either burnt directly to produce heat or anaerobically fermented to produce methane. Lower calorific value derived from methane is of the order of 3300 kcal per kg of dry algae.

(iii) Ocean kelp. Ocean kelp is a kind of sea weed which grows in the coastal areas and also in the high seas. The solar conversion efficiency is higher than that of current land crops. The attraction in this proposal is the utilization of sea areas which have no other use. Yield rates ranges from 300-500 wet tonnes/acre/year. Kelp can be used to produce biogas, burnt as fuel or fed to cattle.

In the case of all plants that flourish in water, they will have to be dried and chopped before being fed to the digester tank.

Selection of Site for a Biogas Plant

Following factors must be considered while selecting the site for a biogas plant.

i) Distance. The distance between the plant and the site of gas consumption should be less in order to achieve economy in pumping of gas and minimizing gas leakage. For a plant of capacity 2 m^3, the optimum distance is 10 m.

ii) Minimum gradient. For conveying the gas a minimum gradient of 1% must be must be made available for the line.

iii) Open Space. The sunlight should fall on the plant as temperature between 15°C to 30°C is essential for gas generation at good rate.

iv) Water table. The plant is normally constructed underground for ease of charging the feed and unloading slurry requires less labour. In such cases care should be taken to prevent the seepage of water and plant should not be constructed if the water table is more than 10 ft. (3 m).

v) Seasonal run off. Proper care has to be taken to prevent the interference of run off water during the monsoon. Intercepting ditches or bunds may be constructed.

vi) Distance from wells. The seepage of fermented slurry may pollute the well water. Hence a minimum of 15 m should be maintained from the wells.

vii) Space requirements. Sufficient space must be available for day to day operation and maintenance. As a guideline 10 to 12 m^2 area is needed per m^3 of the gas.

viii) Availability of water. Plenty of water must be available as the cowdung slurry with a solid concentration of 7% to 9% is used.

ix) Source of cowdung/materials fqr biogas generation. The distance between the material forbiogas generation and the gas plant site should be minimum to economise the transportation cost.

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Different Type of Solar Cooking System

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Introduction

In our country energy consumed for cooking shares a major portion of the total energy consumed in a year. In villages 95% of the consumption goes only to cooking. Variety of fuels like coal, kerosene, cooking gas, fire wood, dung cakes and agricultural waste are used. The energy crisis is affecting everyone. It is affecting the fuel bills of those who use it for heating the houses and cooking their food. The poor of the developing countries who have been using dry wood, picked up from the fields and forests as domestic fuel, have been affected in their own way, due to scarcity of domestic fuel in the rural areas. At present, firewood and cow dung cakes are the most important sources of fuel to cook food. Cow dung is too precious to be allowed to be used for burning and cooking. It is very useful to improve the fertility of the soil, it should be used in proper way. The supply of wood is also fast depleting because of the indiscriminate felling of trees in the rural areas and the denudation of forests. There is a rapid deterioration in the supply of t1ieset'ossil fuels like coal, kerosene or cooking gas. The solution for the above problem is the harnessing of solar energy for cooking purposes.

Thus solar cookers have a very relevant place in the present fuel consumption pattern. Various designs of solar cookers have been developed in our country. The first solar cooker was developed in the year 1945 by Mr. M.K. Ghosh of Jamshedpur a freedom fighter. He developed a box type solar cooker with a reflecting mirror and a copper coil inside, on which the food materials used be placed in pots. Mr. Ghosh also designed a parabolic reflector which was used for some - time as a boiler of Neera(palm juice). Later in 1953 NPL of India developed a parabolic solar cooker. The main reasons for non-acceptance of the devices was the cheap availability of cooking fuel during these days. The problem of harnessing and utilization of solar energy arised after the fuel crisis of the 1970s, which also affected the rural areas.

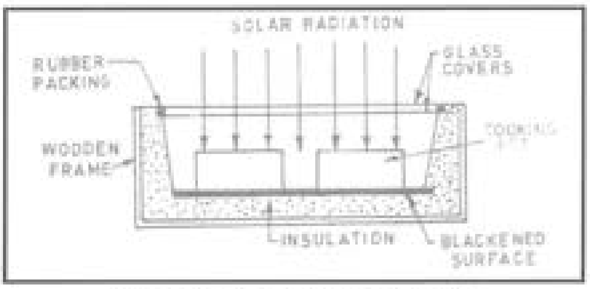

Fig. Principal of box type cooker.

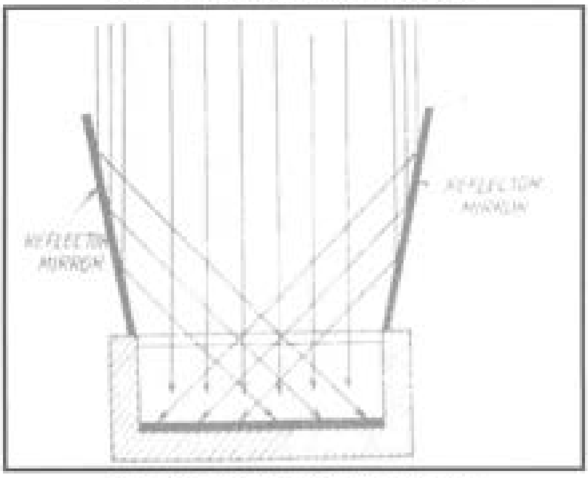

Fig. Reflector type solar cooker.

Basically there are three designs of solar cooker :

(i) Flat plate box type solar cooker with or without reflector,

(ii) Multi reflector type solar oven, and

(iii) Parabolic disc concentrator type solar cooker.

Flat plate box type design is the simplest of all the designs. Maximum no load temperature with a single reflector reaches upto 160°C. In multi reflector oven four square of triangular or rectangular reflectors are mounted on the oven body. They all reflect the solar radiations into the cooking zone in which cooking utensils are placed. Temperature obtained is of the order of 200°C. The maximum temperature can reach upto 250°C, if' the compound cone reflector system is used. With parabolic disc concentrator type solar cooker, temperatures of the order of 450°C can be obtained in which solar radiations are concentrated on to a focal point. Principle of operation of solar cookers is shown in Fig.

Design Principle and Constructional Details of Box Type Solar Cooker.

The principle of operation of box type solar cooker is illustrated in Fig. The solar rays penetrate through the glass covers and absorbed by a blackened metal tray kept inside the solar box. The solar rays entering the box are of short wave length, it degrades into thermal radiation which are of higher wave length. The higher wave-length radiation is not able to pass through the glass sheet. The upper cover of the cooker has two glass sheets in parallel and thus heat loss through re-radiation is minimized from the blackened surface. The loss due to convection is minimised by making the box air tight by providing a rubber strip all round between the upper lid and the box. Insulating material like glass-wool, paddly husk, sawdust or any other material is filled in the space between blackened tray and outer cover of box. This minimises heat loss due to conduction. When this type of cooker is placed in the sun, the blackened surface starts absorbing sun rays and temperature inside the box starts rising. The cooking pots, which are also black ened are placed inside with food material, get heat energy and food will be cooked in a certain period of time depending upon the actual temperature attained inside. The temperature attained depends upon the intensity of solar radiation and material of insulation provided. The amount of solar radiation intensity can be increased by providing mirror or mirrors.

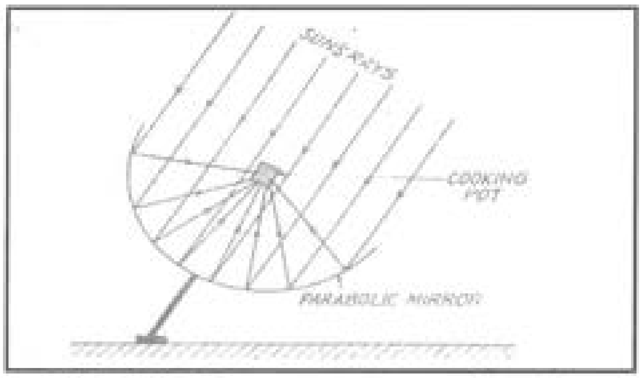

Fig. Principal of concentrator type solar cooker.

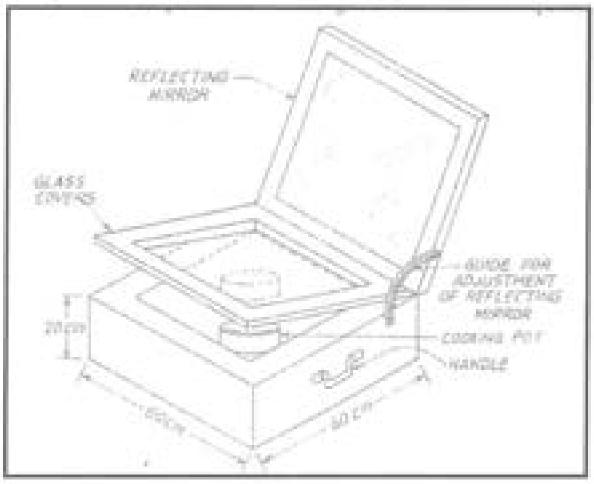

Fig. Details of a box type cooker.

Fig. shows the complete detail of a box type cooker. The salient feature of the solar cooker is that there is no flow phenomenon in the devices. It operates under stagnant condition or equilibrium condition. Therefore the governing parameters of the cooker are different than many other devices. The solar cooker is made up of inner and outer metal or wooden boxed with double glass sheets on it. Absorber tray (blackened tray) is pained black with suitable black paint like boiler interior paint. This paint should be dull in colour so that it can withstand the maximum temperature attained inside the cooker as well as water vapour coming out of the cooking utensils. The top cover contains two plain glasses each 3 mm thick fixed in the wooden frame with about 20 mm distance between them. The entire top cover can be made tight with padlock hasp. Neoprene rubber sealing is provided around the contact surfaces of the glass cover and the cooker box. A small vent for vapour escape, is provided in the sealing. Collector area of the solar cooker is increased by providing a plane reflecting mirror equal to the size of the box, and hinged on one side of the glass frame. A mechanism (guide for adjusting mirror) is provided to adjust the reflector at different angles with the cooker box. A 15° to 25°C rise in temperature is achieved inside the cooker box when reflector is adjusted to reflect the sun rays into the box. In winter, when sun rays are much inclined to horizontal surface, reflector is a most useful addition.

Overall dimensions of a typical model are 60 x 60 x 20 cm height. This type of cooker is termed as family solar cooker as it cooks sufficient dry food materials for a family of 5 to 7 people.

The temperature inside the solar cooker with a single reflector is maintained from 70 to 110°C above the ambient temperature. This temperature is enough to cook food slowly, steadily and surely with delicious taste and preservation of nutrients. M1μdmum air temperature obtained inside the cooker box (without load) is 140°C in winter and 160°C in summer. Depending upon the factors, such as, season and time of the day, type of the food and depth of the food layer, time of cooking with this cooker ranges from 1 hour to 4 hours. Meat should be allowed to stay for 3-4 hours. Vegetables take from ½ to2 ½ hours. All types of Dals can be cooked well between 1 ½ to 2 hours. Rice is cooked between 30 minutes and 2 hours. Cooking is done faster in summer than in winter due to ambient temperature. The best time of the day for cooking is between 11 a.m. and 2 p.m. The time required for cooking is reduced if metallic vessels with a tight lid and painted dull black from outside are used. The layered food are cooked early. The time required for cooking is also inversely proportional to the collector area.

The Merits of box type solar cooker are :

- There is no problem of charring of food and no over flowing.

- Orientation or sun tracking is not needed.
- No attention needed during cooking as in other devices.
- No, fuel, maintenance or recurring cost.
- Simple to use and easy to manufacture.
- No pollution of utensils, house or atmosphere.
- Vitamins in the food are not destroyed and food cooked is nutritive and delicious with natural taste.
- One can relay on cooker's efficiency for longer period.

Demerits of a solar cooker are :

(i) One has to cook according to the sunshine, the menu has to be preplanned.

(ii) One can not cook at short notice and food can not be cooked in the night or over, cloudy days.

(iii) It takes comparatively more time.

(v) Chapaties are not cooked because high temperature for baking is required and also needs manipulation at the time of baking.

The box type cooker has already demonstrated its effectiveness and shown that it is quite economical with less than a two years payback period. So whenever it is practical to use solar cookers, the simple box type cooker is technically and economically suitable and viable. To popularise the cookers government has initiated a scheme for providing subsidy for distribution solar cookers in the country.

Design Principle and Construction of Box type (Multi reflector type) Solar Oven.

The hot-box type of cookers or solar ovens are ideal for baking purposes. The insulated oven has glass windows to admit the solar radiation. Dr. Telkes has developed an oven which is an insulated box with a cooking area vessel 10 square inches, tilted towards the sun and adjusted every half hour as the sun moves during the day. Four slanting reflectors of bright aluminium at the sides of the oven reflect the light down through the window into the oven. Temperatures of 200°C and higher are obtained. An insulating pad is placed over the window to retain the heat of solar radiation entered. Fused salts of hydroxides in tight containers are also used to store the heat for longer periods of time. The performance of this oven is less affected by its frequent positioning and by clouds and winds.

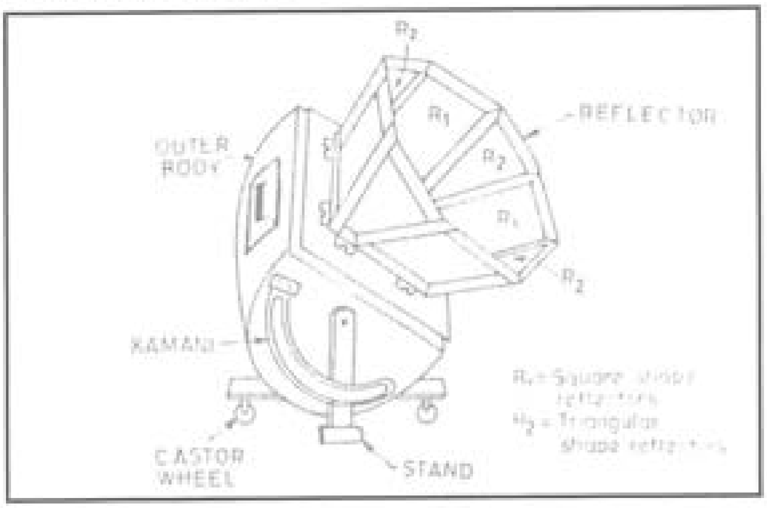

Fig. Isometric view of solar oven.

The solar ovens designed by Central Arid Zone Research Institute (CAZRI), Jodhpur have been installed in villages for demonstration cum test purposes and performance has been found satisfactory, it is shown in Fig. 16.5.3, one of the ovens is of multi-reflector type. This is rather a complicated type of cooker which has got many parts and also needs precision fitting. This type solar oven consists of a well insulated semi cylindrical box made of sheet aluminium (or galvanised iron) and wood. This box is mounted' on a stand on wheels for the facility of shifting from one place to another. There is a rectangular top frame (window) of about 50 cm-sq inside of which is open square of about 35 cm. Two shells are made and the space between them (7 .5 cm) is filled with fibre glass or glass wool or paddy husk insulation. The interior shell is 'painted black. A door of the same insulating material is also made for keeping and taking out of food. The window of the oven consists of two transparent glass sheets (3 mm thick) with a spacing of 2.0 cm. A cradle type stand is also hung loosely from the inside plate of the metal drum. The dimensions of the cradle are 35 cm x 17 .5 cm with two tapered flat ends of 16 cm height. The cooking pots are kept on thee– cradles, which always keep themselves in a horizontal position, irrespective of the sun. There is guide and a hinge which facilitates the box to be fitted at any angle, so that it can track the sun. Eight reflectors made of silvered glass mirrors, four of square shape (35 x 35 X 0.3) and four of triangular shape (35, 25, 0.2 x 0.3). The oven can be manually tiled and oriented towards the sun.

On very clear days, maximum plate temperature in the oven reaches to 350°C in summer season and 250°C in winter season. Practically all types of food preparations like cooking, Roasting, Baking and boiling can be done within 26 to 76 minutes under clear sky conditions. The Bati (a local preparation, generally in Rajasthan and M.P.) can be prepared (baked) in this oven. It is more tasteful than made with conventional fuel (Cow dung cake).

The cost of production of this solar oven is about Rs. 500. The main advantage of this solar oven is that its efficiency is high because ij.s performance is not affected by wind and there are no chances of dust fall in the cooking pot. Moreover the food remains warm if kept inside the oven for hours together even after sunset.

Circular Parabolic Reflector Type Cookers.

These type of cookers were developed by National Physical Laboratory of India at New Delhi as early as 1955. The reflector, about 1.4 m, in diameter, focuses sunlight on to the horizontal bottom of a kettle or plate. Its focal distance is about 15 cm. The hot-plate rating is about 500 watts. The reflector of spun aluminium was supported in a rugged iron frame. This design of cooker is simplest and the cost is low, but drawback is that housewife has to cook the food out of doors in the sun hence it is not favoured.

From the research work and experiment and testing of the various types of the cookers, it has come to the conclusion that a - box type cooker with a single reflector is the cheapest and most effective solar cooker for rural areas.

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Role of Renewable Energy in Development of Farming Sector

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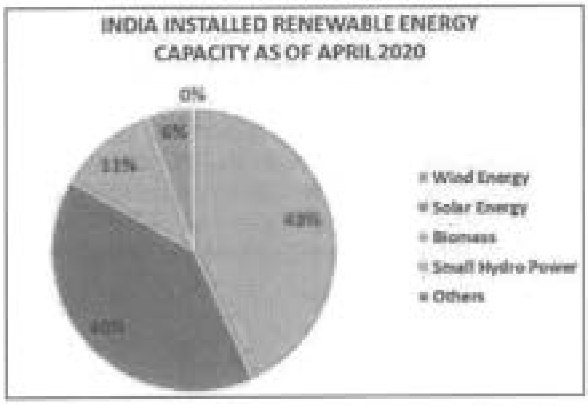
Introduction

India is one of the countries with large production of energy from renewable sources. As of 27 November 2020, 38% of India's installed electricity generation capacity is from renewable sources (136 GW out of 373 GW). In the Paris Agreement India has committed to an Intended Nationally Determined Contributions target of achieving 40% of its total electricity generation from non-fossil fuel sources by 2030. The country is aiming for even more ambitious target of 57% of the total electricity capacity from renewable sources by 2027 in Central Electricity Authority's strategy blueprint. According to 2027 blueprint, India aims to have 275 GW from renewable energy, 72 GW of hydroelectricity, 15 GW of nuclear energy and nearly 100 GW from "other zero emission" sources.



Government of India has also set a target for installation of Rooftop Solar Projects (RTP) of 40 GW by 2022 including installation on rooftop of houses. As of September 2020, 89.22 GW is already operational, projects of 48.21 GW are at various stages of implementation and projects of 25.64 GW capacity are under various stages of bidding. India was the first country in the world to set up a ministry of non-conventional energy resources (Ministry of New and Renewable Energy (MNRE)), in the early 1980s, and its public sector undertakings the Solar Energy Corporation of India is responsible for the development of solar energy industry in India. Hydroelectricity is administered separately by the Ministry of Power and not included in MNRE targets.

Rural Energy in India

Energy is a critical input for economic growth and sustaining development processes. Over one-third of the world's population, largely consisting of the poor in rural areas of developing countries does not have access to electricity. It is estimated that a new power plant would need to be added every two days to meet the increasing global energy demand. This, however, is clearly an unsustainable proposition, and only emphasizes the urgent necessity for developing energy technologies that are environmentally sound, socially acceptable, and economically viable. Lack of access to affordable energy is an important factor contributing to the relatively poor quality of life in rural areas of developing countries. The potential markets of the rural poor are characterized by a high demand for energy for purposes such as lighting, cooking, space heating in the domestic sector; water lifting and transportation in agriculture; and small and medium enterprises (Ali et. al,. 2012).

Use of renewable energy in farming systems can mean several different things. For example, fossil fuels such as oil are non-renewable, so finding alternative ways of fertilising the land and controlling pests that do not depend on chemicals, will normally involve the use of renewable resources. Such methods reduce farmers' vulnerability to the rising price of oil. Renewable energy also includes generation of power to do a number of farm tasks: pumping water for irrigation, for livestock or for domestic use; lighting farm buildings; powering processing operations and others. These forms of renewable energy include solar energy, wind and water power, oil from plants, wood from sustainable sources, other forms of biomass (plant material), and biogas (gas produced from fermentation of manure and crop residues).

India has a strong manufacturing base in wind power with 20 manufactures of 53 different wind turbine models of international quality up to 3 MW in size with exports to Europe, the United States and other countries. Wind or Solar PV paired with four-hour battery storage systems is already cost-competitive, without subsidy, as a source of dispatchable generation compared with new coal and new gas plants in India (Ali et. al. 2012).

Renewable technologies are now supplying or supplementing many on-farm energy requirements, from water pumping to space heating. This is contributing to greater energy security in agriculture through increased diversity of energy sources, more self-supply of energy, and reduced environmental impact.

A strong energy mix of Renewable Energy Sources (RESs) is needed for sustainable development in the electricity sector. India stands as one of the fastest developing countries in terms of RES production. In this framework, the main objective of this review is to critically scrutinize the Maharashtra state energy landscape to discover the gaps, barriers, and challenges therein and to provide recommendations and suggestions for attaining the RES target by 2022. This work begins with a discussion about the RES trends in various developing countries. Subsequently, it scrutinizes the installed capacity of India, reporting that Maharashtra state holds a considerable stake in the Indian energy mix. A further examination of the state energy mix is carried out by comparing the current and future targets of the state action plan. It is found that the installed capacity of RESs accounts for about 22% of the state energy mix. Moreover, the current installed capacity trend is markedly different from the goals set out in the action plan of the state. Notably, the installed capacity of solar energy is four times less than the target for 2020. Importantly, meeting the targeted RES capacity for 2022 presents a great challenge to the state. Considering this, an analysis of the state's strengths, barriers, and challenges is presented. Moreover, strong suggestions and recommendations are provided to clear the track to reach the desired destination.

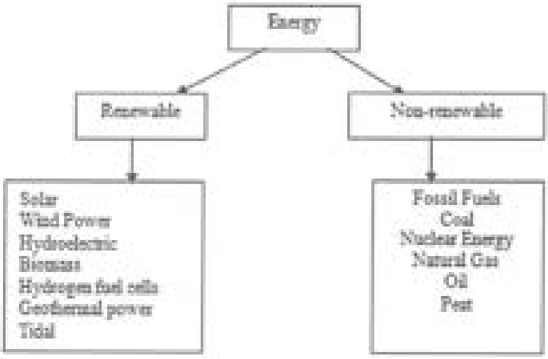
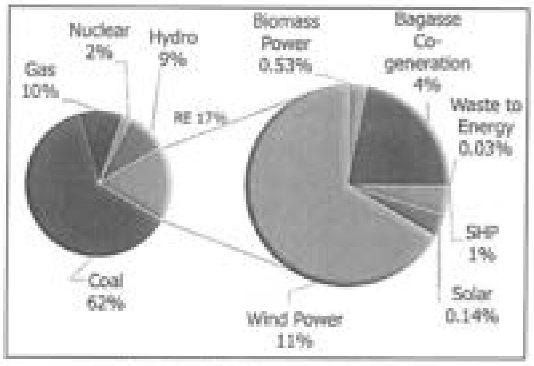


Figure 1: Energy Sources

This can be useful for the government agencies, research community, private investors, policymakers, and stakeholders involved in building a sustainable energy system for the future.

In order to study the progress of RESs in India, the state of Maharashtra is considered. Maharashtra is an important state that is fully focused on installing renewable energy systems. As of 31 March 2018, the total equipped quantity of large hydro energy reserves was about 45.29 GW in Maharashtra. This state separates the country into two parts: North India and South India. The state is well known by its capital city, Mumbai, one of the country's metropolitan cities. It is the third-largest state and is surrounded by the Gujarat, Madhya Pradesh, Chhattisgarh, and Karnataka states. Due to its population, it has many energy consumers who create a strong demand for energy. Yet, this state contributes about 13.89% of India's overall power demand (Thombare et. al. 2016).



Resource wise installed capacity in Maharashtra

Non-Conventional Energy Utilization by Various Countries

Non-conventional energy systems are developed to avoid the constraints imposed by weather conditions, and resources can be used by various sources for long periods without any disturbances. Hybrid non-conventional energy resources are developed in Australia, which involves modeling, techno-economic analysis, and load managing. In one study, there were no restrictions based on daily schedules for hybrid non-conventional resources, and they worked for the whole day without any intervals. In various studies, researchers have developed various controller models for the hourly distribution of non-conventional energy in daily life. In particular, studies were conducted using parameters such as economic, environmental, and reversion for solar photovoltaic (PV), wind, and grid supply energy systems. The energy usage through solar cooling in the Nordic countries was also estimated. The combination of solar plants and co-generation plants was also examined. In India, on-grid power production was designed, and it has seen a huge reduction in part of the cost. The mix of renewable energy sources was studied to satisfy the needs on-grid production with stable operation. In India, many non-urban areas are still facing energy demands and shortages, which could be solved using hybrid non-conventional energy production in a commercial way. An integrated renewable energy optimization model was used to provide electricity for villages through an integrated system. In order to help achieve a pollution-free environment, researchers adopted a combined dispatch strategy, where a hybrid renewable energy system based on lithium ion batteries delivered optimal operational costs. With a hybrid (PV-wind) system, it was found that there was a reduction of CO_2 emissions by nearly 70% to 80%. The growth in solar energy across various countries from 2013 to 2019. It is observed that the generation of solar energy has been increasing from 2017. India also stands as a fast-developing country in terms of solar energy; its rate of growth increased considerably between 2017 and 2019 (Elavarasan et. al. 2020).

Non-Conventional Energy Status and Technological Development in India

In terms of non-conventional energy, India is the leading country in comparison with other countries such as China and the United States. After China, India is the only country that has a population of more than 1.3 billion. The population growth rate in India is 1.10% compared with China, which is at 0.39%. India has always provided strong pathways for significant technologies pertaining to RE implementation and has acknowledged that renewable energy production should be a major contribution to survival. Researchers have reported that these three countries could contribute two-thirds of the clean energy expansion by 2022. The growth of non-conventional energy generation in 2016 was around two-thirds the net capacity of clean energy sources, or 165 GW. This was largely due to the flourishing of solar panels in China and throughout the world, and solar panel energy generation grew by 50% to around 74 GW. Various renewable energy sources such as wind, solar, small hydropower, biomass, and wave energy are used. The growth of renewable energy resources over the past decade in India.

Need For Solar/Wind Energy Technologies in Agriculture

It is common to use kerosene, diesel or propane to power generators in agricultural operations. While these systems can provide power where needed, there are some significant drawbacks, including:

- fuel has to be transported to the generator's location, which may be quite a distance over some challenging roads and landscape;
- their noise and fumes can disturb livestock;
- fuel costs add up, and spills can contaminate the land;
- generators require a significant amount of maintenance and, like all mechanical systems, they break down and need replacement parts that are not always available (Safdar and Heap 2016).

Solar Energy

Widespread use of solar energy for domestic, agricultural, and agro-industrial activities has been practiced almost since the development of civilization. Increasing threat of acute shortage of the commercial sources of energy coupled with serious environmental pollution problems has accelerated interest in the scientific exploitation of renewable sources of energy. Energy available from the sun is inexhaustible and environment friendly. Therefore, the solar energy technologies are likely to play an important role in the near future through a variety of thermal applications and decentralized power generation and distribution systems. The power from the sun intercepted by the earth is approximately 1.8×10^{11} MW. This makes it one of the most promising unconventional energy sources. Solar energy is available in abundance in most part of our country throughout the year. In India,' the annual average daily solar radiation received over the whole of the country is around 1800 J/cm^2/day. Drying of various agricultural produce in open sunlight is an age-old practice. Development of various solar devices for thermal applications such as water heating and space heating, drying, cooking and power generation began during the most century.

Solar Cookers

Two different types of solar cookers i.e. indirect and direct focusing type have been developed in the country. The indirect type solar cookers consisting of an insulated box with transparent window through which sunlight enters into the box have been satisfactorily developed and commercially exploited for domestic cooking. Such solar cookers are being marketed on commercial scale in most of the states through State Energy Development Corporations or other nodal agencies of the Ministry of Non-conventional Energy Sources (MNES), Government of India.

Solar Dryers

Open sun drying of various agricultural produce is the most common application of solar energy. With the objective of increasing the drying rate and improving quality of the produce, natural convection and forced convection type solar dryers have been developed for various commodities. The movement of air in the forced convection solar dryer is through a power blower whereas in natural convection solar dryer air moves through the produce due to natural thermal gradient.

Solar Water Heater

Water heating is one of the most common applications of solar energy for domestic and industrial applications. Similar to solar dryers, water heating systems are also available in natural convection and forced convection designs. Natural convection water heating system also known as thermo syphon water heating system consist of a flat plate solar collector, insulated water storage tank and necessary insulated pipe fittings

Solar Photovoltaic Systems

In solar photovoltaic (SPV) technology the solar radiation falling on a device called solar cell is converted directly into electricity without any environmental pollution. Spy pumping systems are ideal for lifting water for drinking and irrigation without harming the environment. These pumps can be installed in boreholes, tanks, cisterns, or rivers. DC surface pumps are designed for high flow rates at low heads. DC floating pumps are suitable for wide range of flow and head situations (Chel and Kaushik 2010).

How Wind Energy Can Help Farmers

Farmers and ranchers are in a unique position to benefit from the growth in the wind industry. To tap this market, farmers can lease land to wind developers, use the wind to generate power for their farms, or become wind power producers themselves. Farmers and ranchers can generate their own power from the wind. Small wind generators, ranging from 400 watts to 40 kilowatts or more, can meet the needs of an entire farm or can be targeted to specific applications. In Texas and the West, for example, many ranchers use wind generators to pump water for cattle. Electric wind generators are much more efficient and reliable than the old water-pumping fan-bladed windmills. They may also be cheaper than extending power lines and are more convenient and cheaper than diesel generators (Ali et.al 2012).

Effective Utilisation of Hydro Energy On Agriculture

Hydroelectric power comes from the natural flow of water. The energy is produced by the fall of water turning the blades of a turbine. The turbine is connected to a generator that converts the energy into electricity. The amount of electricity a system can produce depends on the quantity of water passing through a turbine (the volume of water flow) and the height from which the water 'falls' (head). The greater the flow and the head, the more electricity produced.

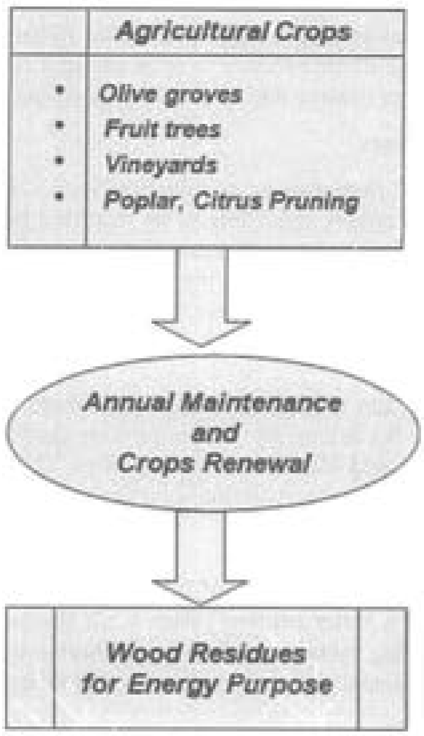
Hydropower is a clean, domestic, and renewable source of energy. It provides inexpensive electricity and produces no pollution. Unlike fossil fuels, hydropower does not destroy water during the production of electricity. Hydropower is the only renewable source of energy that can replace fossil fuels' electricity production while satisfying growing energy needs.

Hydroelectric systems vary in size and application. Micro-hydroelectric plants are the smallest types of hydroelectric systems. They can generate between 1 kW and 1 MW of power and are ideal for powering smaller services such as processing machines, small farms, and communities. Large hydroelectric systems can produce large amounts of electricity. These systems can be used to power large communities and cities (Ogunlade et. al. 2018).

Role of Biomass

Authorities studies reveal that that the forest cover of country is depleting every year at a rate more than 1.5 million hectares. The situation is grave in rural areas. This rate of deforestation is alarming. Much of the wood felled is used as fuel for cooking. Charring and briquetting technologies reduce various problems associated with the management and utilization of biomass in domestic and industrial sectors.

Briquetting of some of the crop residues has becomes cost competitive and the briquettes being used as replacement of firewood in many regions of the country. Domestic biogas plants instal led in our country use cattle dung mixed with an equal quantity of water to maintain 8-9% total solids concentration (TSC) in the influent sl7urry. The effluent discharged from the plants is, in general, col lected into the slurry pits or spread on to the ground for drying before transportation to fields for use as organic manure (Blenkinsopp et. al 2013).



Conclusion

The only realistic solution to the problem go non-renewable is to find sources of renewable energy to replace today's dwindling supplies of affordable and usable fossil energy. Solar energy is the only source of truly renewable energy – renewable at least for the next few billion years. Windmills, falling water, solar collectors, and photovoltaic cells are all sources of renewable solar energy. The most common solar energy collectors are green plants. After all, plants were the original collectors of today's fossil energy. So, it's only logical to look to agriculture as a renewable source of alternative energy for the future. However, we need to be realistic about the extent to which energy from agriculture can replace our current use of fossil energy. While the energy experts may not agree on specific quantities or percentages, the overall limits on energy from agriculture are fairly basic end straight forward.

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A Review On : Status Prospects and Future Thrusts in Biochar Management in Agriculture

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Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperatures (~350–600°C) in an environment with little or no oxygen. The current availability of biomass in India is estimated at about 500 million tons/year. It is estimated that about 93 million tons of crop residues are burned in each year in India. Use of biochar in agricultural systems is one viable option that can enhance natural rates of carbon sequestration in the soil, reduce farm waste and improve the soil quality. Biochar has very good potential as far as soil amelioration is concerned. It not only improves agricultural yields, but also locks away carbon in the soil, which can contribute to a net reduction in carbon emissions. As well as being a renewable energy source itself, the production of biochar can also be used to generate other forms of renewable energy such as liquid and gas biofuels.

Introduction

Agricultural waste is usually handled as a liability, often because the means to transform it into an asset is lacking. Crop residues in fields can cause considerable crop management problems as they accumulate. The major crop residues produced on Indian farms are straws of paddy, wheat, millet, sorghum, pulses, oilseed crops, maize (straw and cobs), cotton and jute sticks, sugarcane trash, leaves, rice husk, groundnut shell, cotton waste, coconut shell, coir pith, tamarind shell, mustard husk, coffee husk, cassava peels etc. fibrous materials, roots, branches and twigs of varying sizes, shapes, forms and densities.. Some of the common agricultural by-products available in large quantities include bagasse, rice husk, groundnut shell, tea waste, casuarina leaf litter, silk cotton shell, cotton waste, oil palm fibre and shells, cashew nut shell, coconut shell, coir pith etc.

Generation of crop residues in Maharashtra is 46 million ton. Maharashtra contributes maximum to the generation of residues of pulses (3 million ton)

Residue burning traditionally provides a fast way to clear the agricultural field of residual biomass and facilitating further land preparation and planting. In Punjab alone, some 70 to 80 million tons of rice and wheat straw are burned annually, releasing approximately 140 million tons of CO_2 to the atmosphere, in addition to methane, nitrous oxide and air pollutants. About three fourths of greenhouse gas (GHG) emissions from agro-residues burning were CH_4 and the remaining one-fourth was N_2O. Burning of wheat and paddy straws alone contributes to about 42% of GHGs. On the other hand, maintenance of a threshold level of organic matter in the soil is crucial for maintaining physical, chemical and biological integrity of the soil and also for the soil to perform its agricultural production and environmental functions Hence, conversion of organic waste to produce biochar using the pyrolysis process is one viable option that can enhance natural rates of carbon sequestration in the soil, reduce farm waste and improve the soil quality Biochar has the potential to increase conventional agricultural productivity and enhance the ability of farmers to participate in carbon markets beyond the traditional approach by directly applying carbon into the soil.

Biochar is applied to agricultural soils using a variety of application rates and preparation techniques. The rate of application and preparation of the biochar will largely depend on specific soil conditions as well as on the materials used to make the biochar. It is often recommended to mix biochar with compost or other materials to inoculate it with nutrients and beneficial organisms. The recommended method for applying biochar will vary depending on how healthy or nutrient-depleted your soil is. Before you use biochar in your own garden or farm, you should first consider the state of your soil.

History of Biochar

Biochar's History as an Ancient Soil Amendment— Biochar is a form of charcoal produced from super-heating biomass. It is found naturally in soils around the world as a result of vegetation fires. Biochar has also been created and used by humans in traditional agricultural practices in the Amazon Basin of South America for more than 2,500 years. Dark, charcoal-rich soil (known as *terra preta* or black earth) supported productive farms in areas that previously had poor, and in some places, toxic soils.

Traditional Production Techniques— The historic method of creating charcoal is to simply pile and cover wood , allowing it to burn slowly with limited air. This method, still used today in developing countries, creates considerable smoke and releases half the carbon dioxide (CO_2) in the original biomass. Whereas charcoal is the result and can be put into soil, its production is not healthy for people or the atmosphere, and all that heat (energy) is wasted.

A New Approach with multiple benefits, the principles of making biochar haven't changed over the centuries but the methods have. Today biochar can be produced in an environmentally friendly way - and it needs to be! Pyrolysis, burning with limited oxygen in a closed system, allows material to be burned at high temperatures and have all the emissions captured. That means the CO_2 and other greenhouse gases are not released but re-burned in the system or broken down into less harmful elements.

In the search for solutions to climate change; growing energy demands; soil exhaustion (just when we need to feed more people); declining water quality; and excessive biomass waste this revolutionary substance called biochar has been rediscovered! But what's so exciting about biochar is our emerging understanding of what it can do for us and the planet beyond increasing the health and productivity of soil for crops and forests

What is Biochar?

Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperatures (350–600°C) in an environment with little or no oxygen. Biochar is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions. The central quality of biochar and char that makes it attractive as a soil amendment is its highly porous structure, potentially responsible for improved water retention and increased soil surface area.

Preparation of Biochar

There are different ways to make biochar, but all of them involve heating biomass with little or no oxygen to drive off volatile gasses, leaving carbon behind. This simple process is called thermal decomposition usually achieved from pyrolysis or gasification. Major thermochemical technologies for biochar production include slow and fast pyrolysis, gasification, torrefaction, and hydrothermal carbonization. Pyrolysis is the temperature driven chemical decomposition of biomass without combustion. In commercial biochar pyrolysis systems, the process occurs in three steps: first, moisture and some volatiles are lost; second, unreacted residues are converted to volatiles, gasses and biochar, and third, there is a slow chemical rearrangement of the biochar. Biochar yield greatly depends on adaption of pyrolysis type. Slow pyrolysis performed at longer residence time and at a moderate temperature (350– 550°C) in absence of O_2 results in higher yield of biochar (30%) than the fast pyrolysis (12%) or gasification (10%). During pyrolysis, lignin, cellulose, hemicellulose, fat, and starch in the feedstock are thermally broken down forming three major products: biochar (solid fraction), bio-oil (partly condensed volatile matter), and non-condensable gases (e.g., CO, CO_2, CH_4 and H_2)

Kiln: Kilns are used in traditional biochar making, solely to produce biochar

Retorts and converters: industrial reactors that are capable of recovering and refining not only the biochar but also products from volatile fractions (liquid condensates and syngases) are referred to as retorts or converters

Retort: The term retort refers to a reactor that has the ability to pyrolyze pile-wood, or wood log over 30 cm long and over 18 cm in diameter

Converters: Produce biochar by carbonizing small particles of biomass such as chipped or pelletized wood.

Slow pyrolysis: refers to a process in which large biomass particles are heated slowly in the absence of oxygen to produce biochar.

Fast pyrolysis: refers to reactors designed to maximise the yields of bio-oil and typically use powdery biomass as feedstock.

Biochar can be produced at scales ranging from large industrial facilities down to the individual farm and even at the domestic level

Feedstock for Biochar Production

A wide range of organic materials are suitable as feedstock for the production of biochar. Biochar can be produced with raw materials such as grass, cow manure, wood chips, rice husk, wheat straw, cassava rhizome, and other agricultural residues. It was reported that the production of biochar with high nutrients depends on the type of raw material used and pyrolysis conditions. Biochar is produced from the residual biomasses such as crop residues, manure, wood residues, and forests and green wastes using modern pyrolysis technology. Agricultural wastes (bark, straw, husks, seeds, peels, bagasse, sawdust, nutshells, wood shavings, animal beds, corn cobs and corn stalks, etc), industrial wastes (bagasse, distillers' grain, etc) and urban/municipal wastes have been extensively used, thus also achieving waste management through its product on and use. The biomass used for the production of biochar is mainly composed of cellulose, hemicellulose, and lignin polymers. Among these, cellulose has been found to be the main component of most plant-derived biomasses, but lignin is also important in woody biomass.

1. Forest residues: Wood chips, Wood pellets, Tree bark
2. Crop residues: straw, nut shells, rice hulls
3. Organic wastes: grains, bagasse, olive waste, chicken litter, dairy manure, sewage sludge, paper sludge.

Factors Affecting Biochar Properties

The reaction conditions during the pyrolysis process are mainly responsible for producing biochar. The factors such as feedstocks, temperature, size of the particle, heating rate, etc mainly influence biochar properties. These factors have a direct effect on the yield of biochar rather than its quality. The detailed knowledge of analyzing biochar properties is important for determining the biochar application. Various biomass from different sources such as plant materials, agricultural residues, and biomass from wood, solid wastes, etc has been used for producing biochar.

Pyrolysis is a commonly used method for biochar production, which is generally carried out at 400–1000°C. Solid wastes and animal wastes produce more biochar compared to other biomass materials such as wood biomass, agricultural residues, etc.

Feedstocks Biomass is considered as a complex solid material, composed of biological, organic, or inorganic material which was derived from living or living organisms. Biomass is characterized into two types woody biomass and non-woody biomass. Woody biomass essentially includes tree residues and forestry residues. The attributes of wood biomass are low dampness, low debris, high density and calorific value. Non-woody biomass comprises animal waste, industrial and agricultural solid wastes. The attributes of non woody biomass are high debris, high dampness, low density and calorific value.

Among different attributes of biomass feedstock, moisture content has great impact on biomass formation. The moisture in the biomass can exist as different forms such as liquid water, water vapour and adsorbed within the pores of biomass. Higher moisture content in biomass majorly inhibits formation of char and raises amount of energy needed to attain the pyrolysis temperature. Low moisture content in the biomass is preferable for biochar formation because of the impressive decrease in the heat energy and the reduction of time needed for the pyrolysis process which makes that biochar formation economically feasible when compared with biomass with high moisture content.

Pyrolysis is the most famous method for exchanging biomasses over to biochar through thermochemical decay process under an oxygen-denied environment at the raised temperature. Pyrolysis temperature influences physicochemical properties and structure of biochar, for example, elemental components, pore structure, surface area and functional groups. The impact of pyrolysis temperature on such properties can be attributed to the influx of volatiles at high temperatures Contingent upon the conditions, pyrolysis cycles can be grouped into three fundamental classifications:

(i) Slow pyrolysis (temperatures <300°C)
(ii) Moderate pyrolysis (temperatures of 300–500°C)
(iii) Quick pyrolysis (temperatures more prominent than 500°C).

Expanding the residence time at low pyrolysis temperature (300°C) brought about a slow decrease in biochar yield and reformist expansion in pH and iodine adsorption number of biochar. Nonetheless, expanding residence time at high pyrolysis temperature (600°C) had little impact on biochar yield or pH, while it diminished iodine adsorption number of biochar.

Pre-treating the biomass before pyrolysis influences biochar characteristics. The common pre-treatment methods available are immersing the raw materials in solution and particle size reduction of biomass. The reduction of biomass particle size results in high biochar yield. For example, pine wood biomass was pre-treated by immersing the biomass in a dilute acidic solution. Pre-treatment methods such as nitrogen and metal doping can influence biochar production and solution pre-treatment such as soaking or steaming can influence the elemental composition and properties of biochar while the baking method can increase the carbon content and reduce the oxygen and moisture content of biochar. The potential biomass for biochar generation, utilized either independently or as mixes. Contingent upon the innovation utilized, the practical execution is as often as possible restricted by the moisture or mineral substance of the biomass. For example, the presence of chlorine and soluble base metals can cause consumption. Because of various production technologies and biomass, the properties of the produced biochar can go broadly. While components, for example, hydrogen (H), O, nitrogen (N), and sulphur (S) are volatilized during pyrolysis, minerals, for example, phosphorus (P), K, calcium (Ca), magnesium (Mg), and silicon (Si) remain and their concentrations increment in the resultant biochar. The occurrence of harmful compounds or components in biochar can either be an outcome of polluted biomass during pyrolysis/gasification.

Benefits of Biochar

1. Strong ability to retain hydrocarbons and other organic compounds.
2. High cation exchange capacity (CEC).
3. High physical adsorption capacity within the macropores (up to 10 microns) to micropores.
4. Able to maintain soil structure.
5. High carbon content.
6. Able to improve water holding capacity.
7. Provide viable environment for beneficial microbes.
8. Sequestrate carbon.

Effect of Biochar on Soil Properties

1. **Physical Properties**
    1. Biochar reduces soil bulk density.
    2. It facilitates better soil aeration.
    3. Biochar modifies the soil structure and texture through changes in physical process.
    4. Biochar lessens the hardening of soils.
    5. Biochar helps to reclaim degraded soils.
2. **Chemical Properties:**
    1. Biochar reduces soil acidity by increasing pH (also called the liming effect).
    2. It helps soil retain nutrients and fertilizers (Lehmann, 2006 in Hansen, 2008).
    3. Improves soil fertility by two mechanisms: (1) by adding nutrients to the soil (such as K, to a limited extent P, and micronutrients); (2) by retaining nutrients from other sources including nutrients from the soil itself.
    4. Biochar also increases C, N, and P availability to plants, because it absorbs and slowly releases fertilizer.
    5. It increases in the soil levels of available Ca, Mg, P, and K.
    6. It helps to prevent fertilizer runoff and leaching, allowing the use of less fertilizer and diminishing agricultural pollution to the surrounding environment
    7. Biochar mitigates the impact of hazardous pesticides and nitrogen fertilizers on the local environment and ecology.
    8. Biochar absorbs excess of complex fertilizers and pesticides in soil, thus lessening their impacts.
    9. Increased cation exchange capacity (CEC) of soil colloids.
3. **Biological properties:**
    1. Biochar increases soil microbial respiration by creating space for soil microbes.
    2. It increases soil biodiversity and soil-life density in the presence of organic carbon.
    3. Biochar increases arbuscular mycorrhizae fungi. Soil aggregation also improves due to increased fungal hyphae.
    4. Biochar helps to lessen the impacts of termites on the biomass in agricultural field.
    5. The presence and density of earthworms increase in soil treated with biochar over time.
    6. Ants are more repellent to the freshly added biochar, and over a period of time the biochar's impact on ants lessens.

Methods of Biochar Application to Soils

1. Top dressing
2. Incorporation with composts and manures

3. Uniform topsoil mixing
4. Incorporation with liquid manures and slurries
5. Deep-banded application in rows

Rate of Application

1. Experiments have found that rates between 5-50 t/ha have often been used successfully.
2. Lower application rate : good organic fertilizer
3. Higher application rate : increases carbon credit benefit
4. In nitrogen-limiting soils it could fail to assist crop productivity as a high C/N ratio leads to low N availability.

Limitation of Biochar

1. Some time it disturbs the physical and chemical balances of nutrients in the rhizosphere.
2. Helps in growth of undesirable weeds.
3. Manufacturing is relatively expensive.
4. Lack of feed stock / biomass to produce biochar.

Effect on Soil Health and Crop Growth

Biochar application in soil acts as a conditioner and plays a much more important role in improving crop growth than as a fertilizer itself. The improvement of crop growth may result from an increase of pH and CEC. Bio-char applications to soil are also able to reduce the emissions of other greenhouse gases due to better aeration (less frequent occurrence of anaerobic conditions) and possibly by greater stabilization of C. Biochar applications to soil also have the potential to decrease environmental pollution because biochar's are very efficient absorbers for dissolved ammonium, nitrate, phosphate and other ionic solutes as well as hydrophobic organic pollutants.

Biochar can be used as a soil amendment to improve soil quality, to increase soil pH and CEC, improve water quality, increase soil moisture retention, reduce emission of greenhouse gases from soil, leaching of nutrients, soil acidity, irrigation and fertilizer requirements and also to reclaim degraded and spoiled land. The application of biochar to soil has been shown to improve crop yields which could be due to direct or indirect effect. The direct effect explained by fact that biochar being concentrated during pyrolysis contains higher amount of nutrients than the biomass from which they are prepared. The indirect effect is due to improvement in soil physical, chemical and biological properties due to biochar application. Organic manures improve soil properties and nutrients use efficiency but in tropical condition they mineralize quickly resulting lesser benefits, while a fraction of biochar remains in soil in a very stable form for a long time.

Effect of Biochar on Soil Aggregation

A soil which is well aggregated has a good structure and as a result provide good medium for nutrient and water movement into the soil and uptake by plants. Certain polysaccharides secreted by microorganisms also increase the adherence of soil colloidal particles. Application of biochar provides refuge to microorganisms and also prevents them from predators and desiccation. The microorganisms secrete polysaccharides which increase soil aggregation.

Effect of Biochar on Soil Water Holding Capacity

Biochar application boost up the available water content of the soil up to 97 percent and saturated water contents 56 percent. Biochar amended soil retained 15 % more moisture contents as compared controlled treatment. Biochar application increased the water retention capacity of the soil because it increase soil porosity and also due to adsorptive nature of biochar.

Future Perspectives

Biochar is a unique renewable resource, which has a significant potential to address several environmental issues we have been encountering in recent years including remediation of pollutants in soil, water, and gaseous media. This could synergistically improve soil, water and air quality, carbon sequestration, and greenhouse gas emissions mitigation. Since the biochar quality and performance varies significantly depending on feedstock types and pyrolysis conditions, future progress in biochar development is expected to centre around 'tuning' the properties for tailored applications. Currently, the International Biochar Initiative has taken significant strides in fostering stakeholder collaborations, industry practices, and set environmental and ethical standards to support biochar systems for the safe and economically viable system. Unifying the methods and developing standards for the production process, characterization, and life cycle analysis both from experimental and model approaches will bring biochar producers, users, and policy makers towards collaborative efforts to discover cost effective uses of biochar for effective environmental and agronomic applications.

Biochar activation is another important area to tailor the application of biochar for removal of specific contaminants. For example, tannery waste activation of pine wood-derived biochar attributed to enhance adsorption of ammonium-N and other organic and inorganic pollutants from wastewater; chemical activation of biochar showed increased adsorption of pollutants with low desorption. Further research is needed to identify various activation methods and adsorption and desorption mechanisms of diverse contaminants.

Microbial communities and their distribution in biochar-amended soil have not been well examined, especially with respect to biochar properties *(e.g.,* pH, particle size, micro porosity, nutrient content, ion-exchange capacity). With growing concern of soil pollution and infertility, biochar application could open-up new opportunity not only for their remediation but also as a source of macro and micro-nutrients (captured from waste material) in nutrient deficient soils.

Further study is needed to critically examine the role of microbes in soil remediation and mineralization processes. Another important research area could be towards agronomic welfare, about biochar surface chemistry and surface interaction with various soil constituents especially 'micronutrients' binding on biochar and their exchange mechanisms.

There is also a growing interest in applications of biochar in wastewater treatment, especially removal of toxic compounds from various industries. Thus, biochar treatment could serve as a pre-treatment for the removal of toxic compounds for subsequent biological treatment. There is a need to conduct detailed study to understand the removal mechanisms of the toxic compounds.

Conclusion

Biochar may be suitable and viable technology for transferring atmospheric carbon to soil by the process of soil carbon sequestration. A huge amount of carbon can be stored in soil for hundreds to thousands of years by converting agricultural and forestry residues, wastes etc. to biochar through simple pyrolysis techniques. From the several studies it was proved that biochar may be potential soil amendments or conditioner that improves soil fertility and crop productivity by directly affecting soil pH and CEC. Studies have shown that biochar is also capable of absorbing toxic metals and contaminants which are harmful to the entire ecosystem. Biochar comes with the appeal of being a low cost and low- environmental-impact strategy for remediation of environmental pollutants and climate change mitigation. However more concentrated effort is required to standardize the package of practices of biochar application in different cropping system under integrated plant nutrient management practices system (IPNMS). Besides this it is necessary to evaluate the side effects of biochar application for the sustainable and productive agriculture.

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Design of Large Scale Fixed Dome Biogas Plant for Power Generation

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Abstract: The energy is an important input in all sector of any countries economy. The standard of living of any country can be directly related to per capita energy consumption. In dairy large numbers cattle's are available and they produce huge amount of the dung each day this cow dung degrades aerobically and after sometimes it emits foul odor and makes environment polluted all around. Also emits methane (CH4) which is 20 times more harmful to environment than carbon dioxide (CO2). The disposal of cow dung is a great problem in dairy as the dung raises a lot of problems for human health and ecology system. Keeping the dung for long time emits pungent odor and attract hordes of flies which hazardous to human health. Now a days as fossil fuels are depleting day by day there is need to increase the use of renewable energy sources and for reduce the dependency on fossil fuels for our energy needs. At Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, University dairy produces a huge amount of dung everyday which has a problem of disposal of such waste. To handle the waste in an efficient manner large scale modified fixed dome biogas has been constructed. A 50 m^3 fixed dome biogas plant has been constructed to produce biogas. The biogas could be used to produce electricity to enlighten the dairy sheds in the nights.

Keywords: Biogas, modified, dung, methane, energy.

Introduction

The natural resources of energy are being depleted exhaustively and uneconomically in a developing country. India is a developing country, it needs to reorient its different methods of use of energy so that it can be used effectively as well as economically. Biogas is becoming very much useful clean, efficient, economical and pollution free source of energy. Setting up a biogas plant is the best alternative to utilize and handle the waste in efficient manner. Biogas plant stabilizes the waste properly and makes it free from odour. Biogas is not only an excellent alternative source of energy, but also a step towards stopping global warming.

Biogas has emerged as a promising renewable technology to convert agricultural, animal, industrial and municipal wastes into energy. Biogas development can be integrated with strategies to improve sanitation as well as reduce indoor air pollution and greenhouse gases. Currently, the total biogas production in India is 2.07 billion m^3/year which is quite low as compared to its potential, which is estimated to be in the range of 29-48 billion m^3/ year.

Biogas technology provides an alternative source of energy mainly from organic wastes. It is produced when bacteria degrade organic matter in the absence of air. Biogas contains around 55-65% of methane, 30-40% of carbon dioxide and small quantities of hydrogen, nitrogen, carbon monoxide, oxygen and hydrogen sulphide. The calorific value of biogas is appreciably high around 4700 kcal/m^3 or 20 MJ/m^3 at around 55% methane content. The gas can effectively be utilized for generation of power through a biogas based power-generation system after dewatering and cleaning of the gas. In addition, the slurry produced in the process provides valuable organic manure for farming and sustaining the soil fertility (MNRE, 2010). 1.0 m^3 of biogas is equal in energy content to 1.7 L of bioethanol, 0.97 m^3 of natural gas and 1.1 L of gasoline.

At Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, university dairy has 214 cattle which produces 2000 kg dung every day. The dairy department was facing a problem of disposal of animal waste. They require an electricity for lightning in the evening, pumping water from bore well and heat energy in product making such as paneer, butter etc. In order to recycle the animal waste into energy and to reduce dependence on conventional energy a large scale biogas plant required.

Considering the aforesaid facts a large scale modified janta fixed dome biogas plant was constructed and installed at university dairy farm to mitigate the daily energy needs of Department of Animal Husbandry and Dairy Science under the Department of Unconventional Energy Sources and Electrical Engineering, Dr. PDKV, Akola.

Material and Methods

Cow dung availability at university dairy

At university dairy there are 214 cattle which produces large amount of dung. Daily cow dung produce at the Department of Animal Husbandry and Dairy Science, Dr. PDKV, Akola is given in the table 1.

Table 1 : Dung production per day (kg) at university dairy

Sr. No.	Animals	No. of animals	Dung Production, kg/day
1	Calves	143	1186
2	Cow	62	620
3	Buffalo	09	135
	Total Dung Production, kg/day		**1941**

Capacity of biogas plant is depend on two parameters:

1) Availability of the feeding material (cow dung) and

2) Biogas requirement for power generation.

From table 1 it is revealed that the total cattle dung production in university dairy is approximately 1941 kg/day.

Assume 10% losses hence total cow dung available = 1,747 kg/day.

A 20 m^3 biogas plant for thermal application is already installed and in working condition at same site which utilised 500 kg dung per day.

Thus cow dung available = 1,247 kg/day.

Cow dung required for 50 m^3 biogas = 50/0.04 = 1250 kg/day.

Hence the biogas plant has been developed with the capacity of 50 m^3/day of biogas production and hydraulic retention time of 30 days. The substrate cow dung will be feed daily with water in 1:0.3 ratio.

Design of Modified Janta Biogas Plant

Assumption

- Dung produce by small cow = 08 kg/day
- Dung produce by small buffalo = 10kg/day
- Dung produce by big cow = 10 kg/day
- Dung produce by big buffalo = 15 kg/day
- One kilogram cattle dung will produce 0.04 m^3 (40 liter) biogas
- Cattle dung required for production 1 m^3 biogas = 25 kg.
- Total cattle dung production = 1941 kg/day
- Assume 10% losses
- hence total cow dung available = 1,747 kg/day
- A 20 m^3 biogas plant plant for thermal application is already installed and in working condition at the same site which utilized 500 kg dung per day.
- Cow dung available = 1,747- 500 = 1247 kg/day
- Capacity of biogas plant = 1247 x 0.04 = 49.88 ≈ **50 m^3/day**
- Cow dung required for 50 m^3 biogas = 50/0.04 = 1250 kg/day

Total volume of the digester (Vd) : $Vd = \frac{\text{daily feed density}}{\text{x retention period.}}$

- $Vd = 69.6\ m^3 \approx 70\ m^3$

- Daily feed = 1875 kg/day (cow dung + water).
- Density of input slurry = 1080 kg/m^3.
- Hydraulic retention time = 30 days.
- Volume of Gas holder is 40 - 60 % of the capacity of the biogas plant.
- Volume of digester (Vd) = $\frac{\pi D^2 H}{4}$
- Where "D" is diameter and "H" is height of digester
- Assume D = H (For big Janta model biogas plant diameter height ratio is 1:1)

Height, $H = \frac{\text{total volume of digester} \times 4}{\pi D^2}$

Diameter, D = Vd×4π3

Accord. above formulae diameter of digester (d) = **4.46 m**

Volume of digester :

(Vd) = $\frac{\square\square\square\square^{\square\square}\square\square}{\square\square}$

Vdigester = 69.6 m^3 ≈ **70 m^3**

Volume of Dome (Vg) :

VDome = $\frac{2\square\square\square\square^3}{3}$

Vg = 21.17 m^3 ≈ **22 m^3**

Total volume of plant :

V = Vdigester + Vdome = V = 70+22 = **92 m^3**

Biogas plant description

On the basis of availability of cow dung and requirement of power modified janta biogas plant has been designed and installed for 50 m^3 capacity under Department of Unconventional Energy Sources and Electrical Engineering, Dr. PDKV, Akola at university dairy.

Table 2. Dimensions of 50 m^3 modified janta biogas plant

Sr.no	Components	Symbol	Dimension, mm
1	Diameter of digester	D	4460
2	Inner radius of digester	R	2230
3	Depth of digester	H	4460
4	Height of outlet opening	H1	920
5	Height of smaller portion of outlet chamber	H2	2175
6	Length of bigger portion of outlet chamber	M	5180
7	Width of bigger portion of outlet chamber	N	4300
8	Diameter of mixing tank	R	1050
9	Height of mixing tank	P	600

Detail of biogas plant

The biogas plant has following four main components.

i) **Inlet tank**: It is cylindrical in shape used as slurry mixer where water and dung are mixed. It was constructed 30 cm above the ground level. A 30 cm diameter HDPE pipe was connected from inlet tank to digester at 90 cm above from the bottom of digester and laid 75^0 degrees with horizontal for the smooth feeding of slurry.

ii) **Digester**: It is underground cylindrical wall portion made with bricks, sand and cement. The mixed slurry from the inlet tank is stored into the digester where the anaerobic digestion takes place. In the digester methanogenic bacteria consumes the dung material and produces methane at temperature ranges from 35 to 37 ^{0}C.

iii) **Dome:** It is hemispherical in shape constructed above the digester. The amount of gas produce in the digester gets collected and stored in the dome. The produced biogas exerts pressure on the digested slurry so that it is removed out from the outlet.

iv) **Outlet chamber:** It is that part of the plant through which digested slurry moves out from digester. These components are shown in fig.1.

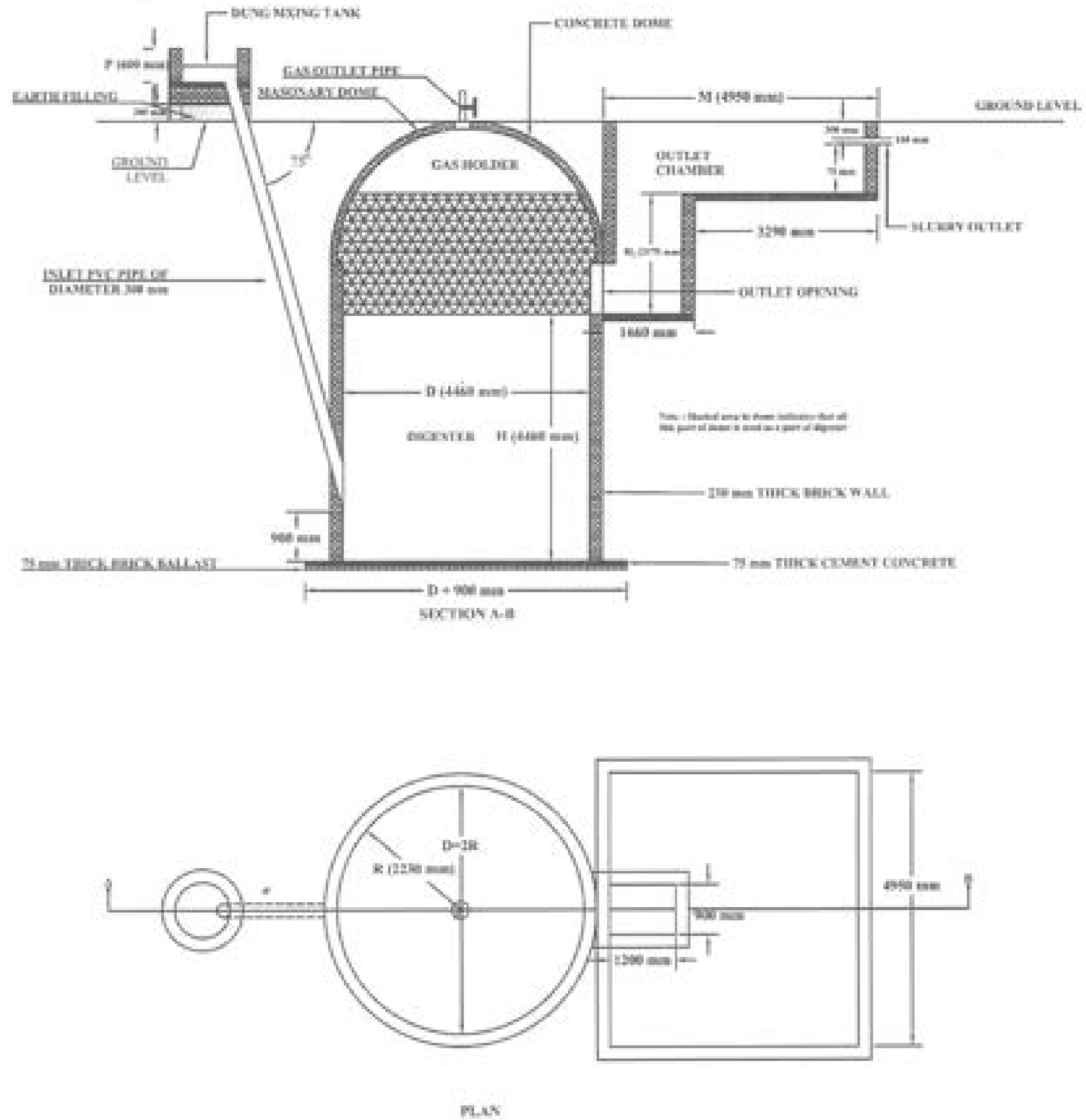


Fig. 1 : Schematic view of 50 m^3 modified janta biogas plant

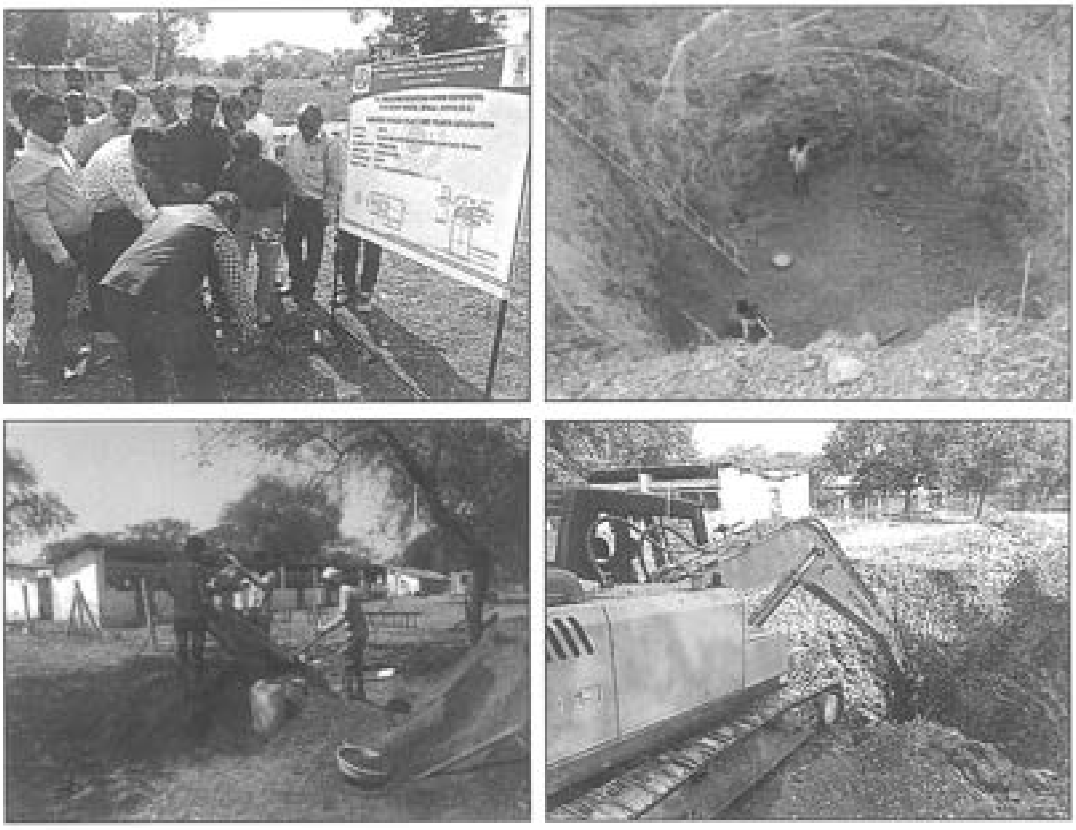
Working of Modified Janta Biogas Plant

The cattle dung and water are mixed properly in the ratio of 1:0.3 in digester up to the height of its cylindrical portion. After 30 days retention time gas started generate and accumulate in the dome. Gas exerts pressure on the slurry and displaces through the outlet chamber and slurry comes out from outlet. The quantity of usable gas was determined by calculating increased slurry volume in inlet and outlet chambers. After 30 days of retention period the biogas was started generating and accumulated in the dome. The schematic view of 50 m^3 modified janta biogas plant is shown in fig. 1 and the detailed dimensions of the modified janta biogas plant is given in table 2.

Table 2 : Dimensions of 50 m^3 modified janta biogas plant

Sr.no	Components	Symbol	Dimension, mm
1	Diameter of digester	D	4460
2	Inner radius of digester	R	2230
3	Depth of digester	H	4460
4	Height of outlet opening	H1	920
5	Height of smaller portion of outlet chamber	H2	2175
6	Length of bigger portion of outlet chamber	M	5180
7	Width of bigger portion of outlet chamber	N	4300
8	Diameter of mixing tank	R	1050
9	Height of mixing tank	P	600

Construction of Biogas Plant



Excavation work with JCB and Poclain

Foundation and digester construction

Installation of Inlet pipe

Results and Discussion

The observations were carried out on the basis of total solid content, carbon, hydrogen, nitrogen and oxygen content, nutrients composition in fresh and digested slurry, daily biogas production and gas composition in biogas etc.

Table no 3 depicted that the average total solid content in digested slurry was decrease as compared to fresh cattle dung.

Table 3 : Total solid content in fresh cow dung and digested slurry.

Sr. No	Avg. TS in fresh cattle dung (%)	Avg. TS in digested slurry (%)
1	20.30	10.47
2	19.97	12.97
3	20.40	10.13
4	20.57	10.63

Carbon, nitrogen and oxygen content in digested slurry were increased whereas the hydrogen content was decreased in the digested slurry from the biogas plant outlet as depicted in table no. 4.

Table 4 : Carbon, Hydrogen, nitrogen and oxygen content in fresh cow dung and digested slurry

Element	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Oxygen (%)
Fresh cow dung	27.51	13.44	1.78	53.76
Digested slurry	32.09	6.82	1.94	56.95

The essential nutrients Nitrogen (N), Phosphorous (P) and Potassium (K) required for the plant growth were effectively increased in digested slurry as shown in table no. 5

Table 5 : Nutrients composition in fresh cow dung and digested slurry

Nutrients	Nitrogen N	Phosphorous P	Potassium K
Cattle dung	1.13	0.75	0.55
Digested slurry	1.33	0.90	0.68

The daily biogas production was observed for the month of December 2020. The average daily biogas production was found to be 42.06 m^3/day in the month of December 2020.

Table 6 : Daily biogas production and gas composition in biogas.

Day	Date	Input Dung, kg	Amount of gas, m^3/day	CH4,%	CO2,%	H2S, PPM
1	01/12/2020	1250	35	55	44	744
2	02/12/2020	1250	40	55	44	750
3	03/12/2020	1250	40	54	45	744
4	04/12/2020	1250	41	55	43	743
5	05/12/2020	1250	42	55	43	743
6	06/12/2020	1250	41	55	43	736
7	07/12/2020	1250	42	56	43	755
8	08/12/2020	1250	44	55	42	833
9	09/12/2020	1250	42	56	43	855
10	10/12/2020	1250	40	57	40	843
11	11/12/2020	1250	40	56	40	792
12	12/12/2020	1250	41	57	40	788
13	13/12/2020	1250	42	58	42	802
14	14/12/2020	1250	41	58	42	748
15	15/12/2020	1250	42	58	41	734
16	16/12/2020	1250	44	58	41	822

Day	Date	Input Dung, kg	Amount of gas, m^3/day	CH4,%	CO2,%	H2S, PPM
17	17/12/2020	1250	42	58	42	748
18	18/12/2020	1250	40	58	42	745
19	19/12/2020	1250	40	60	39	733
20	20/12/2020	1250	41	58	42	712
21	21/12/2020	1250	42	58	41	713
22	22/12/2020	1250	41	58	41	712
23	23/12/2020	1250	42	58	40	822
24	24/12/2020	1250	46	58	41	748
25	25/12/2020	1250	45	57	42	745
26	26/12/2020	1250	46	58	41	733
27	27/12/2020	1250	44	58	41	712
28	28/12/2020	1250	42	57	42	713
29	29/12/2020	1250	46	58	41	630
30	30/12/2020	1250	45	52	38	648
31	31/12/2020	1250	46	50	39	602

Conclusion

- A large scale modified janta biogas plant was designed and installed for 50 m^3 capacity successfully at university dairy Dr. PDKV, Akola.
- The average production of biogas in the month of December 2020 was found to be 42.06 m^3/day.
- The average proportion of methane and carbon dioxide was found to be 57.8% and 42 % respectively.

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Theme IV

Agricultural Entrepreneurship and Rural Development

Rural Development : A Role of Self Help Group

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Abstract: Self-help groups (SHGs) play today a major role in poverty alleviation in rural India. Rural Development is a very dynamic process which involves in improving the socio-cultural, environmental, political and economic well-being of the rural poor. The SHGs have been playing a vital role to eliminate poverty , illiteracy and health hazards problems through the way of group efforts, The concept of rural development is very important for a country like India, where majority of population is under rural areas The self help group SHGs approach is a new instance into the field of rural development which aims at improving the living condition of the rural poor by creating common efforts. The present study is focused on role of self help group in rural development. The study is based on primary data survey was conducted through a prepared schedule and informal interview with each SHG groups in the sample villages . The study revealed that 80 per cent of the members were self employed and meet their urgent need 0.89 per cent of the members recorded to increase their confidence level in decision making in the democratic, economic, social and cultural spheres of life.

Keywards: Rural development, self help group

Intrduction

In India, majority of the people live in rural area and are engaged in Agriculture, earning a subsistence wage. Women are vital part of the Indian economy and employment to build their empowerment.

India has been able to develop its own model of microfinance organization in the form of savings and credit groups known as Self-Help-Groups (SHGs) which are bank linked. Rural women of India have been benefited by the Self Help Groups (SHG). The socio-economic benefits include economic self independence, economic self reliance, participation in village affairs and awareness about education.

In Maharashtra as per proverb "many a little makes a mickle ",tremendous change taken place in economics of rural region by self help groups. There are 132024.82 lakh SHGs in Maharashtra in year 2013-14.

Women are vital part of the Indian economy, constituting one third of the national labour force and forming a major contributor to the survival of family. Eighty nine percent of total female labour involved in agriculture and allied industrial sector. Women have extensive work loads with dual responsibility for farm in general and livestock and household production in particular. Women contribute considerably to household income through farm and non farm activities as well as through work as landless labourers. More than 90 per cent of rural women in India are unskilled, restricting them to low paid occupations. Women generally have no control over land and other productive assets, which largely excludes them dependent on high cost informal sources of credit to secure capital for consumption and productive purposes.

Self Help groupswomen members are involved in most of the activities in animal husbandry enterprise like dairy, poultry, goat rearing and vermicomposting, Food Processing, Floriculture, Olericulture, Forest product. Rural Indian Self Help groups womenmembers are extensively involved in agriculture activities. However, the nature and extent of their involvement differs with the variations in agro-production systems.

The SHGs are characterized in empowerment of women through focusing attention on women below the poverty line to provide self-employment by imparting training in different activities and improving the available local skills improves the status of women in the family as well as in the society, creates better awareness to health, education and environment among rural people. Promotes and ensures the human rights of women and at all stages of their life. It offers not only economic opportunities but also a change to learn new skills, make wider social contacts and experience. It creates an environment through positive economic and social policies for full development of women to enable them to realize their full potential. Thus the SHGs certainly play an important role in women empowerment. Since the overall empowerment of women is crucially dependent on economic empowerment, these SHGs could generate income and employment to build their empowerment.

Objectives

1) To workout economics of agro base activities selected by SHGs .
2) To examine the impact of SHGs on rural development

Methodology

The present study has been based on primary data, out of seven tehsil three tehsil namely, Murtizapur, Akot and Akola and two villages from each tehsil were selected randomly. The data were collected by survey method a specially designed schedule and personal interview of SHG members. The major agro based activity taken up by SHG were dairy farming, Vermicompost, Goat raring and Horticulture (Turmeric) were considered for the study. The data pertains to the year 2018-19.Total 60 respondents who having worked related to agro base activities were selected from the villages. The details activities was given below.

Table 1 : Distribution of SHGs as per activities

Sr. No	Income generating Activity	No of SHG
1.	Dairy	15
2.	Vermicompost	15
3.	Goat rearing	15
4.	Horticulture (Turmeric)	15
	Total	60

Result and Discussion

Table 1 : Age and literacy level of respondent

Age (years)	No of respondent	Education	No of Respondent
18-24	7 (11.66)	Upto 10th	35 (58.33)
25-35	27 (45.01)	Upto 12th/Diploma	17 (28.33)
35 and above	26 (43.33)	Graduate and above	8 (13.34)
Total	60 (100)	Total	60 (100)

(Figures in parenthesis are percentage to total)

From the Table1 it can be observed that, the total 60 respondents interviewed , about 11.66 percent belong to 18-24 years, 45.01 percent is 25-35 years and 43.33 percent belong above 35 years.In case of education 58.33 percent respondents found upto 10th , 28.33 percent upto 12th /diploma holder, and 13.34 percent is in graduate and above.

Table 2 : Occupational pattern of selected respondent

Occupation	No of respondent	Monthly income (Rs)
Agrillabour	33 (54.87)	2000-3000
Agriculture	21 (35.12)	Below 5000
Other activity	6 (10.01)	Upto 7000
Total	60 (100)	

(Figures in parenthesis are percentage to total)

From the Table 2.it is observed that , 54.87 per cent respondent was worked as agrilabour and their monthly income was Rs 2000-3000/-.,35.12 per cent belongs to agriculture and their monthly income found to be below Rs 5000/- .However, only 10 percent of respondent belong to other activityviz. carpenter, shepherd and their monthly income is upto Rs7000/-.

Table 3 : Economics of selected Agro base activities by SHGs

Sr. No.	Total cost	Gross return	Net return	B;C ratio
Dairy(Rs/)	24757.29	42236.48	17479.19	1.70
Goat	19315.59	32185.01	12869.42	1.66
Horticulture (Turmeric)	26640.15	40513.09	13872.94	1.52
Vermicompost	26875.28	48149.46	21274.18	1.80

It was observed from the Table3that , the total net income received from Vermicompost enterprise was Rs21274.18 per year. The Input output ratio of the vermicmpost activity was1.80.The net return from Dairy,Goat, and Horticulture was Rs17479.19, Rs.12869.42 and Rs13872.94 respectively. The B:C ratio was 1.70,1.66 and 1.52 indicated the profit received from the selected activities by Dairy ,Goat and Horticulture which leads to encourage the self help group towards the empowerment of the rural development.

Table 4 : Socio Economic Impact of SHG

Statement (N=60)	Before joining	After joining
Confidence in decision making	30 (50)	53 (89)
Self employed	25 (41.67)	48 (80)
Able to contribute towards family income	22 (36.67)	47 (78.33)
Women Empowerment	18 (30)	43 (71.67)
Devloped saving habit	23 (38.33)	49 (81.67)
Skill upgradation	33 (55)	52 (86.67)
Understand the banking system	17 (28.33)	47 (78.33)
Awareness in health and education	21 (35)	51 (85.00)
Awareness in social issue(child marriage, dowery, old age and widow pension)	27 (45)	50 (83.33)

(figures in bracket indicate percentage to the total)

It is observed from the Table 4.,that the confidencs in decision making devloped in 89 per cent, followed by skill upgradation 86.67 per cent, Awareness in health and education 85 per cent, awareness in social issue 83.33 per cent, it indicate the overall good impact of SHGs.

Conclusion

The selected economic activity provided additional income to the self help group which leads to the tremendous contribution towards the development of self reliant, self confident and social empowerment among the members of SHGs which contribute toward the process of rural development.

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Marketing Behaviour of Green Chilli Growers in Amravati District

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Abstract: The present research was undertaken on topic "Marketing Behaviour of Green chilli Growers in Amravati District of Vidarbha region of Maharashtra state' purposively on the basis of major area under green chilli production. An exploratory design of social research was used for present study aims at assessing the marketing behaviour of green chilli growers. Two talukas namely Amravati and Morshi of Amravati district was selected for the study as having major area under green chilli crops and based on highest cultivable area according the green chilli crop area min 0.40 ha. From each of the selected taluka's five villages was selected purposively based on highest area under green chilli production. Thus, total ten villages were selected for the study, total 120 green chilli growers constitute the sample size for the study. 60 respondents were selected form Amravati and Morshi talukas each.

The findings of the research study revealed that the majority (58.33%) of Green chilli Growers belonged to medium category of marketing behaviour index range (33.34 to 66.67%) followed by (21.67%) of Green chilli Growers were belonged to high marketing behaviour having index above 66.67 . Whereas (20.00%) of Green chilli Growers belong to low level of marketing behaviour of index up to 33.33. it is concluded that the average marketing behaviour score of the Green chilli Growers was 47.29.

Keywords: Marketing Behaviour, Green chilli growers, Green chilli, marketing.

Introduction

Chilli is considered one of the important commercial crops in India and enjoys a pride place and unique position in our economy. Chilli a crop of prosperity, has profound influence on men and matter. Different varieties are grown for vegetables, spices, condiments, sauces and pickles. Both green and dried chillies are the important components of our routine diet. It gives the required pungency, colour, taste and flavour to dishes. Chillies are rich in vitamins, especially in vitamin A and C. They are also packed with potassium, magnesium and iron. Chillies have long been used for pain relief as they are known to inhibit pain messengers, extracts of chilli peppers are used for alleviating the pain of arthritis, headaches, burns and neuralgia. It is also claimed that they have the power to boost immune system and lower cholesterol. They are also helpful in getting rid of parasites of gut. Chilli is one of the most important commercial spice crops of India. It is grown almost throughout the country. Chilli has gained its popularity through more than 400 varieties available all over the world with different pungency, size, shape and colours and its usage. It is also called as hot pepper, cayenne pepper, sweet pepper, bell pepper, etc. Some varieties of chillies are famous for red colour because of the pigment 'capsanthin,' others are known for biting pungency attributed to 'capsaicin.' India is the only country which is rich in many varieties with different quality factors. Chilli is grown as an herbaceous seasonal crop having compact, erect, prostrate and determinate growth habit. The fruit is berry, short, long or rounded according to variety with colours ranging from green, yellow, red, purple, black, brown in the course of its ripening. Both green and dried chillies are the important components of our routine diet. Different varieties are grown for vegetables, spices, condiments, sauces and pickles.

The problems of chilli Growers are numerous, however, lack of market infrastructure and price fluctuation seems to be major bottleneck in the sustained development of vegetable production. The chilli marketing problems in rural areas have not been studied in a systematic way even though numbers of studies have been conducted in the country. Presently development of marketing infrastructure to solve the problems of chilli Growers in rural areas is the primary concern of the government.

Material and Methods

Locale of the study

The present investigation was carried out in Amravati district of Vidarbha region of Maharashtra state. The above district was selected purposively on the basis of major area under green chilli cultivation

Selection of green chilli Growers

The list of green chilli Growers was obtained from TAO, Department of Agriculture. From each taluka five villages was selected in respect of green chilli Growers and from each village, twelve green chilli Growers was selected randomly. Thus, total

120 green chilli Growers i.e., green chilli Growers was the sample size for the study. 60 green chilli Growers was selected form Amravati and Morshi talukas each

Measurement of Marketing Behaviour of Green Chilli Growers

Marketing Behaviour of Green Chilli Growers

Marketing behavior of green chilli Growers as involvement of green chilli Growers in the marketing activities like reason for selling on particular time, to whom sale, place sale , mode of transport, distance of market , grading , packaging, reasons for selling at particular place or particular agency , terms and condition of sale, price of produce time of sale and source of marketing information these 13 activities was considered and index will developed to measure the marketing behaviour of green chilli Growers by considering the score and scaled values of the components it was measured on two point continuum as yes and no and scored as 1 and 0 respectively for measurement of marketing behaviour score was assigned to each selected item. Further it was converted into marketing behaviour index with the help of following formula.

$$\text{Marketing Behaviour Index} = \frac{\text{Obtain score}}{\text{Obtainable score}} \times 100$$

After determining marketing behaviour index it was further categorised as low, medium and high respectively on the basis of equal interval method.

S. No.	Marketing activities	Green chilli Growers Frequency	
		Yes (1)	No(0)
A	**Reasons for selling at a particular period/time**		
1	Highly perishable		
2	Cold storage facility will available		
3	Quality will not good		
4	Financial urgency		
B	**Whom do you sale the produce**		
1	Directly to the consumer		
2.	Brokers/middle men		
3.	To the exporters through commission agent		
4.	Traders through contract farming		
C	**Place of sale**		
1	In the village		
2	In the nearby bazaar		
3	Amravati city		
4	Other than district place		
D	**Modes of transport for selling produce**		
1	Motorcycle		
2	Reefer containers		
3	Mini truck		
4	Bus		
E	**Distance of the market**		
1	Below 10 km		
2	11 km – 20 km		
3	21 km -40 km		
4	Above 40 km		
F	**Reasons for selling at a particular place**		
1.	Market was very near to place		
2.	The better transport facilities available to the market		

S. No.	Marketing activities	Green chilli Growers Frequency	
		Yes (1)	No(0)
3.	Better prices were available in the market		
G	**Reasons for sell to a particular agency**		
1	The agency will very nearer one		
2	Better price		
3	No time to engage self to sale chilli directly to the consumer		
4	Immediate cash payment		
5	Previous agreement		
H	**Terms and condition of sale**		
1	Pre-harvest contract		
2	Deferred cash payment		
3	Ready cash payment		
I	**Price of product**		
1	Fluctuating		
J	**Time of sale**		
1	Immediately after harvest		
2	When in need of cash		
3	When in will convenient		
K	**Sources of market information**		
1	Newspaper		
2	Television		
3	Mobile phone calls		
4	Market agents		
5	Personally visited to market		
L	**Product sell after grading**		
1	No grading		
2	Grading based on size		
3	Grading based on size, shape		
4	Grading based on size, shape and colour		
M	**Mode of packing green chilli**		
1	Polybag		
2	Aluminium foil		
3	Sachet		
4	Cotton cloth		

Total score for all the items gave marketing behaviour score of an individual. based on the total score obtained by the green chilli Growers, following categories of marketing behaviour was made by using the formula mean ± SD.

Results and Discussion

Marketing activity wise Marketing Behaviour

The marketing behaviour was assessed against thirteen major components regarded as marketing activities. Table shows the data in this regard.

Table 1 : Distribution of the according their marketing activities wise marketing behaviour

S. No.	Marketing activities	Green chilli Growers Reactions	
		Frequency	Percentage
A	**Reasons for selling at a particular period/time**		
1	Highly perishable	120	100.00
2	Cold storage facility will not available	85	70.83
3	Quality will not good	17	14.16
4	Financial urgency	18	15.00
B	**Whom do you sale the produce**		
1	Directly to the consumer	8	06.66
2.	Brokers/middle men	102	85.00
3.	To the exporters through commission agent	05	04.16
4.	Traders through contract farming	05	04.16
C	**Place of sale**		
1	In the village	03	02.50
2	In the nearby bazaar	09	07.50
3	Amravati city	105	87.50
4	Other than district place	03	02.50
D	**Modes of transport for selling produce**		
1	Motorcycle	104	86.66
2	Reefer containers	08	06.66
3	Mini truck	04	03.33
4	Bus	04	03.33
E	**Distance of the market**		
1	Below 10 km	32	26.66
2	11 km – 20 km	36	30.00
3	21 km -40 km	46	38.33
4	Above 40 km	6	05.00
F	**Reasons for selling at a particular place**		
1.	Market was very near to place	104	86.66
2.	The better transport facilities available to the market	10	08.33
3.	Better prices were available in the market	6	05.00
G	**Reasons for sell to a particular agency**		
1	The agency will very nearer one	40	33.33
2	Better price	20	16.66
3	No time to engage self to sale chllii directly to the consumer	25	20.83
4	Immediate cash payment	15	12.50
5	Previous agreement	20	16.66
H	**Terms and condition of sale**		
1	Pre-harvest contract	05	04.16
2	Deferred cash payment	20	16.66
3	Ready cash payment	95	79.16
I	**Price of product**		
1	Fluctuating	111	92.50
2	Fixed	09	07.50

S. No.	Marketing activities	Green chilli Growers Reactions	
		Frequency	Percentage
J	**Time of sale**		
1	Immediately after harvest	103	85.84
2	When in need of cash	14	11.66
3	When in will convenient	03	2.5.00
K	**Sources of market information**		
1	Newspaper	4	03.33
2	Television	10	08.33
3	Mobile phone calls , sms.	62	51.66
4	Market agents	4	03.33
5	Personally visited to market	40	30.33
L	**Product sell after grading**		
1	No grading	90	70.00
2	Grading based on size	20	16.66
3	Grading based on size, shape, colour.	10	08.33
M	**Mode of packing green chilli**		
1	Polybag	99	82.50
2	Gunny bag	19	15.83
3	Cotton cloth	02	01.66

Activity wise marketing behavior of green chilli growers Table - 1 shows that distribution of the green chilli growers according to reasons of selling. It was observed from table no 1 that as regard with as reason of selling was a particular period/time cent per cent green chilli experience highly perishable nature of green chilli. Followed by Cold storage facility will not available (70.83%) & third reason was quality will not good (14.16%). As regarced whom do you sale the produce higher percentage (85.00%) of green chilli growers expressed that Brokers/middle men for selling the green chilli followed by (06.66%) Directly to the consumer. As regarded Place of sale green chilli higher percentage (87.50%) in Amravati city followed by (07.50%) In the nearby bazaar. As regarded Modes of transport for selling produce (86.66%) Motorcycle followed by (06.66%) Reefer containers. As regarded Distance (21 km -40 km) of the market higher percentage (38.33 %) followed by (11 km – 20 km) percentage was (30.00%).also regarded Reasons for selling at a particular place higher percentage (86.66%) Market was very near to place followed by (08.33%). As regarded as reasons for sell to a particular agency higher percentage (33.33%), Followed by (20.83%) No time to engage self to sale chllii directly to the consumer. also regarded Terms and condition of sale higher percentage (79.16%) Ready cash payment, followed by (16.66%) Deferred cash payment. As regarded Price of product higher percentage (92.50%) Fluctuating followed by Fixed (07.50%). also Time of sale higher percentage (85.84%) Immediately after harvest followed by When in need of cash(11.66%). As regarded Sources of market information higher percentage (51.66 %) Mobile phone calls , sms. followed by (30.33%) Personally visited to market. Also regarded as Product sell after grading higher percentage (70.00%) No grading followed by Grading based on size (16.66%).also regarded as Mode of packing green chilli higher percentage (82.50%) Polybag followed by Gunny bag (15.83%).

A. Overall Marketing Behaviour

The information regarding overall marketing behaviour of green chilli presented in Table 2.

Table 2 : Distribution of the Green chilli Growers according to their overall Marketing Behaviour

S. No.	Marketing Behaviour index	Green chilli Growers (n= 120)	
		Frequency	Percentage
1	Low (up to 33.33)	24	20.00
2	Medium (33.34 to 66.67)	70	58.33
3	High (Above 66.67)	26	21.67
	Total	120	100.00

Mean = 47.25

It was observed from Table 2 that, the majority (58.33%) of Green chilli Growers belonged to medium category of marketing behaviour index range (33.34 to 66.67%) followed by (21.67%) of Green chilli Growers were belonged to high marketing behaviour having index above 66.67 . Whereas (20.00%) of Green chilli Growers belong to low level of marketing behaviour of index up to 33.33, The average marketing behaviour score of the Green chilli Growers was 47.29.

Conclusion

Thus, it is concluded that The fact that majority of the Majority of the green chilli Growers (58.33%) had medium level of Marketing behaviour is a clear indication of the progressiveness of the green chilli growers. As green chilli marketing is one of the economically viable enterprise in agriculture sector, therefore more number of agriculture graduates should come forward, organize, create a group and tap this opportunity and address the present problem of unemployment in agriculture. As most of the farmers had medium innovativeness, still there is a need to expose the green chilli production to recent developments in agricultural technologies and motivate them to adopt the latest and new technologies by organizing group discussions, meetings, study tours and field trips to hi-tech Market yard

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Factors Affecting on Adoption Gap of Dairy Management Practices

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Abstract: India has made remarkable strides in the area of dairy development. India is continued to remain the largest producer of milk in the world. The rapid growth of milk production in India has been mainly because of the increase in the number of animals rather than that of the improved productivity. Therefore, it is necessary to examine the factors affecting on adoption of improved dairy management practices by the dairy farmers. An exploratory design of social research was used. The present study was carried out in the five villages of Akola Panchayat Samiti and five villages of Barshitakali panchayat samiti under Akola district of Maharashtra state. From each selected village, ten dairy farmers were randomly selected as respondents, who are adopting dairy farming continuously since last five years and have more than four milch animals. In all, total 100 dairy farmers were randomly selected from ten villages of Akola and Barshitakali panchayat Samiti of Akola district of Maharashtra state. The findings revealed that the more than half of the dairy farmers (55%) observed in medium level category of technology adoption gap about improved dairy management practices. The age of respondent was found positive and highly significantly correlated with their technological adoption gap. Whereas, all other variables except dairy farming experience that are education, land holding, annual income, herd size, family type, family size socio-economic status, economic motivation, scientific orientation and knowledge were having negative and highly significant correlation with gap in adoption of improved dairy management practices.

Keywords: Adoption, Dairy farmers, Dairy management Practices

Introduction

India has largest livestock population in the world and India has made remarkable strides in the area of dairy development. India is continued to remain the largest producer of milk in the world. The rapid growth of milk production in India has been mainly because of the increase in the number of animals rather than that of the improved productivity. However the maximum milk is produced from selected pockets of the most of the states of the country. It is also reported that Maharashtra state generates about 1.6 crore litres of milk every day, out of which Kolhapur district of western Maharashtra alone is producing about 20 lakh litres of milk. As against this, Vidarbha region produces only 80,000 litres of milk per day. To overcome this situation Maharashtra Govt. launched Vidarbha Development Programme Package (VDPP) in the year 2004 to increase the milk production in Vidarbha region. Therefore, it is necessary to examine the technological gap in adoption of improved dairy management practices by the dairy farmer.

Methodology

The present study was carried out in the five villages of Akola Panchayat Samiti and five villages of Barshitakali panchayat samiti under Akola district of Maharashtra state. An exploratory design of social research was used. From each selected village, ten dairy farmers were randomly selected as respondents, who are adopting dairy farming continuously since last five years and have more than four milch animals. In all, total 100 dairy farmers were randomly selected from ten villages of Akola and Barshitakali panchayat Samiti of Akola district of Maharashtra state.

Results and Discussions

I. Profile of Dairy Famers

The data with respect to the profile of the dairy farmers indicated that, 44 per cent of respondents were of middle aged category followed by 40 per cent of them were old age group category of above 50 years and in young category i.e. upto 35 years in age were 16.00 per cent. It could be observed that seven per cent of respondents were illiterate and remaining 93 per cent were literates. Within literates 34 per cent dairy farmers were educated upto high school followed by 24 per cent of the dairy farmers having education upto primary school level, 22 per cent have middle school and remaining 13 per cent had education upto college level. Further it is noticed that 48 per cent of the respondents were in semi-medium land holding group. The equal per cent of the respondents were in small and medium land holding category i.e. 25.00 per cent. Only one respondent was each in the large and marginal category of land holding. It is revealed that near about equal percentage (45% and 44%) of the dairy farmers having annual income of Rs. 50,000 and in between Rs. 50,001 to Rs. 1,00,000, respectively. The remaining 11 per cent of the dairy farmers belonged to annual income group of Rs. 1,00,000 and above. It is seen that majority of the respondents (66.00%) having dairy farming experience between 7 to 12 years, followed by 23 per cent of them having upto 6 years dairy farming experience. The remaining 11 per cent of the dairy farmers having 12 years and above dairy farming experience. Majority of the respondents (74.00%) having herd size between 5-10 herds, followed by 19 per cent of them were having upto 4 herds and remaining seven per cent having more than ten herds. Majority of the respondents (56.00%) were in joint family type and 44 per cent were in nuclear family type. The data regarding family size revealed that majority of the respondents (42.00%) having 6 to 11 members in their family, followed by 31 per cent of them were having upto 5 members in their family and remaining 27 per cent having more than 11 members in their family. More than two third of the respondents (64.00 per cent) had medium level of economic motivation, followed by nearly one third of them (28.00 per cent) were had low level of economic motivation and only 8.00 per cent of them belonged to high category of economic motivation. Majority of the respondents (60.00%) having medium level of scientific orientation, followed by 22 per cent of them were having low level of scientific motivation and remaining 18 per cent belonged to high level of scientific orientation category. Similar findings reported by Bindakatti et. al.(2012).

II. Dependent Variables

a. Practicewise Adoption gap in dairy management practices

The practice wise adoption gap in dairy management practices revealed that the majority of the respondents (90%) were not adopting the separate shed for milking, followed by 85 per cent of them not adopted the feeding of pregnant animal (12 to 15 kg green fodder, 5 to 6kg dry fodder &1.5 concentrates mixtures) and 82 per cent not adopted the vaccination of cow/buffalo. The technology gap in adoption of feeding of buffalo/cow1st four days after calving (2 kg wheat bhusa,1.5 kg jiggery,5 kg green fodder, 5 kg dry fodder reported by 80 per cent dairy farmer and the practice of direction of cattle shed (North-South) not adopted by 80 per cent of the dairy farmer.

Equal per cent of the dairy farmers (75%) were not adopted the practices proper feeding to pregnant animals, quantity of green fodder (15to20 kg) and number of cattle in flock (10 to 20), respectively. The improved dairy management practices were not adopted by the dairy farmers were grooming of cattle (72%), proper time of artificial insemination (2 months after calving (70%), detection of systems of heat period of buffalo (65%), quantity of colostrum should be fed (1/10 of body weight (65%), detection of heat period (urination frequency, bellowing excitement, mounting on other animals, restlessness) (56%) and space required for adult cow (15 to 12 sq ft) (56%).

Less than half of dairy farmers were not adopted the proper time of pregnancy diagnosis (60 to 90 days after services) (45%), sprinkler water on body of cow/buffalo in summer season (twice in a day) (45%), Breeding age of cow/buffalo (2.5 to3 years) (30%), descript breed for-milk production-Nagpuri, Murhah, Jersey (25%),proper time to fed colostrum (22%) and descript breed for -dairy -Nagpuri, Murhah, Jersey (20%).

b. Adoption Gap level

The efforts have been made to find out the distribution of the respondents based on their level of existing gap in adoption of improved dairy management practices and data in this regard presented in the Table 1.

Table 1 : Distribution of respondents according to the gap in adoption in dairy management practices

Sr. No.	Category	Respondents (n=100)	
		Number	Percentage
1	Low (Upto 33.33)	21	21.00
2	Medium (33.34 to 66.66)	55	55.00
3	High (66.67 and above)	24	24.00
	Total	**100**	**100.00**

It is found from Table 1, that majority of respondents (55%) belonged to medium category of adoption gap about improved dairy management practices, followed by 24 per cent of them who were observed in high level of technological gap, and remaining 21 per cent of the respondents belonged to low level of technological gap.

III. Relational Analysis

The data depicted in Table 2 reported that the age of the respondents was positive and highly significantly correlation with their adoption gap. Whereas, all other variables except dairy farming experience that are education, land holding, annual income, herd size, family type, family size socio-economic status, economic motivation, scientific orientation and knowledge were having negative and highly significant correlation with technological gap in adoption of improved dairy management practices.

Table 2 : Coefficient of correlation of selected characteristics of the dry land farmers' with their Adoption Gap

Sr. No.	Independent variables	r value
1	Age	0.278**
2	Education	-0.341**
3	Dairy Farming Experience	0.012NS
4	Land holding	-0.440**
5	Annual Income	-0.763**
6	Herd Size	-0.511**
7	Family Type	-0.287**
8	Family Size	-0.308**
9	Socio Economic Status	-0.653**
10	Economic Motivation	-0.443**
11	Scientific Orientation	-0.526**
12	Knowledge	-0.473**

**Significant at 0.01 level of probability

*Significant at 0.05 level of probability

NS - Non Significant

The negative trend indicated that as these variables score decreased, the technological adoption gap was increased. The probable reason might be for understanding and adoption of the improved dairy management practices, dairy farmers may be lacking in proper education level, more land holding, high annual income, more numbers of milch animals, joint family or more number of members in family, higher socio-economic status, economic motivation, scientific orientation and most important knowledge about improved dairy management practices. This could be a reason for negative correlation between these variables of the dairy farmers and their adoption of improved dairy management practices.

Conclusions

More than half of the dairy farmers observed in medium level category of adoption gap about improved dairy management practices. The age of the respondent was found positive and highly significantly correlated with their technological adoption gap. Whereas, all other variables except dairy farming experience that are education, land holding, annual income, herd size, family type, family size socio-economic status, economic motivation, scientific orientation and knowledge were having negative and highly significant correlation with technological gap in adoption of improved dairy management practices. The negative trend indicated that as these variables score decreased, the technological adoption gap was increased. Therefore it is implied from the study the administrator and policy makers should take care about above selected characteristics of the dry land farmers and should take maximum effort to divert the dry land farmers towards dairy farming as their subsidiary occupation.

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Role of Institutions in Creating Entrepreneurship Among Self Help Group Women

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Abstract: The SHG movement definitely proved to be a spark to spread the fire of empowerment of women through development of concept of group entrepreneurship. Self Help Promoting Institutions (SHPIs) provide the necessary assistance like financial, training and skill development, procurement of raw material, infrastructure, marketing and technological support, guidance to SHGs in various matters concerning micro-enterprises. Therefore this research was conducted with the specific objectives to study and analyze the profile of SHG entrepreneurs to study kind of enterprises/ business activities taken up by SHGs, to know the kind of institutions supported to SHG entrepreneur in technology and financial assistance.

The study was conducted in Chandrapur district of Maharashtra. Pretested structured interview schedule was administered for data collection. The statistical analyses were carried out by using SPSS 18.0 Software. The findings of the study revealed that majority (122) SHGs of the region have been benefitted and received services/support from the Institutions. Government institutions are more involved in SHG entrepreneurship development than non-government organization in region. Most of the SHGs (94 and 98) of region have received financial assistance in the form of government subsidies under different schemes and assistance support, technical training, and skill development from respective institutions. More than ¾th of the members of SHGs did attend training programs before starting or upgrading the enterprise. Majority of SHGs (72) member attended the training program on entrepreneurship development. However, there was marginal improvement in skill development, marketing linkages, and managerial ability respectively from institutional support.

Keywords: Self help promoting institutions (SHPI), Self Help Group, Entrepreneurship

Introduction

The size of women population in India indicates the potential strength of women in the total human resource in the country. Women (especially rural women) are vital development agents who can play a significant role in the economic development of a nation Women as a group and poor women in particular, have been adversely affected by the progress of growth and economic transformation (Pan and Devi 2015). It has also been realized that the widespread poverty and stunted economic growth can be overcome only by gainful and sustainable economic participation of women. National development will be sluggish, if the economic engine operates only at half power. All round development of the women has been one of the focal points of planning process in India. Many strategies were designed with the evolution of Self Help Groups (Santha 2013).

Self Help Group is an organization of rural poor, particularly of woman that deliver micro credit to undertake the entrepreneurial activity. Self-help group disburses microcredit to the rural women for the purpose of making them enterprising women and encouraging them to enter into entrepreneurial activities. Thus, entrepreneurship is most important factor for economic development of rural women. (Kuratko and Richard 2001).

To bring the rural women into the national stream of the economy, many efforts have been made both by the government and non-governmental organizations During the planning era, a number of institutions or agencies have been set up to work as Self Help Promoting Institutions (SHPIs) to render assistance to women entrepreneurs by giving them training and providing financial and marketing assistance. Both the governments as well as the NGOs are facilitating development of such enterprises at the grass root level.

Though the initiative efforts of government, NGOs for promotion of microenterprises through self help groups showed positive impact in building self-confidence, socio-economic development, micro-enterprising and economic-empowerment of women, it is necessary to know how effective SHGs in developing microenterprises and self employment. Are the efforts enough and sustainable to ensure the necessary income to members? Therefore this research was conducted with the specific objectives-

- To study kind of enterprises/ business activities taken up by SHGs.
- To know the kind of institutions supported to SHG entrepreneur.
- What supports are given to SHG women entrepreneurs by SHPIs.

Methodology

The study was conducted in Chandrapur district of Maharashtra. Chandrapur district comprises 15 blocks. The women SHGs who are engaged into some income generating entrepreneurial activity from two or more years selected for study.

The purposive random techniques were used to select SHG's. For this purpose the list of SHG's entrepreneurs of each block were collected from District Rural Development Agencies, Mahila Arthik Vikas Mahamandal, Commercial banks of year 2014-15. Out of total number of SHGs started business activities, 150 SHGs, 10 SHG's of each block were chosen by lottery method for the study.

A descriptive survey research design was used in the study to assess the key factors that affect the growth of SHG women in enterprises (entrepreneurs) in Chandrapur district. Pretested structured interview schedule was administered for data collection. The study includes interaction with SHG's grass root level extension workers, government departments and other institutions that support the Self Help Group in various kinds.

Both, average and percentage analyses were carried out to draw meaningful interpretations. The statistical analyses were carried out by using SPSS 18.0 Software.

Results And Discussion

Activities Undertaken by SHGs

The type of enterprises started by SHG entrepreneurs in particular region reflects their potentiality, Interest, and demand of the product in the market. Moreover, distribution of the SHGs according to the income generating activity undertaken by group is categorized as in table.

Table 1 : Activities Undertaken by the SHG Members

Enterprises Activity undertaken	Respondents	Per cent
Farming	14	9.3
Sale of Farm Produce	32	21.3
Forest Produce Business	13	8.7
Dairy	19	12.7
Goat and Poultry	10	6.7
Processed Food	25	16.7
Other (Grocery shop, cloth shop, bangles shop, stitching and tailoring, bag making, pottery, tea selling, mess, anganwadi, meal, kerosene)	37	24.7
Total	**150**	**100.0**

Above **Table 1** presents data pertaining to the distribution of the SHGs with respect to the business activities undertaken by them. The results show that majority (24.7 per cent) of the SHG members are engaged in other types of enterprising activities like the grocery shop, cloth shop, bangles shop, stitching and tailoring, bags making, pottery, tea selling, operating mess service, anganwadi meal service and kerosene selling, However, those involved in the dairy and farming related business are relatively low. Yatnalli et al., (2012) have stated that SHG's sustainability is dependent on the type of activity undertaken by them as the benefits are directly linked to the same.

Type of Institutions Responsible for Running the SHGs

Different statutory agencies are responsible for the operations or monitoring of the activities of the SHGs. In the study area also, the SHGs are run by different institutions such as various government and non government institutions. The data pertaining to this attribute is presented in the following table.

Table 2 : Type of Institutions Responsible for Running the SHGs

Group run by Institutions	Respondents	Per cent	
Panchayat Samiti	65	43.3	Chi-square = 50.853 P=<0.05
Agricultural Department	9	6.0	
Mahila Arthik Vikas Mahamandal (MAVIM)	51	34.0	
Non-Government Organisations	25	16.7	
Total	**150**	**100.0**	

Table 2 indicates result regarding the information about the agencies, which are responsible for running the SHGs .The data shows that majority i.e. 43.3 per cent of the SHGs are run by the Panchayat Samitis followed by 34.0 per cent by the MAVIM. However, SHGs, which are run by the NGOs and Agricultural Department, are relatively less (**Fig.1**).

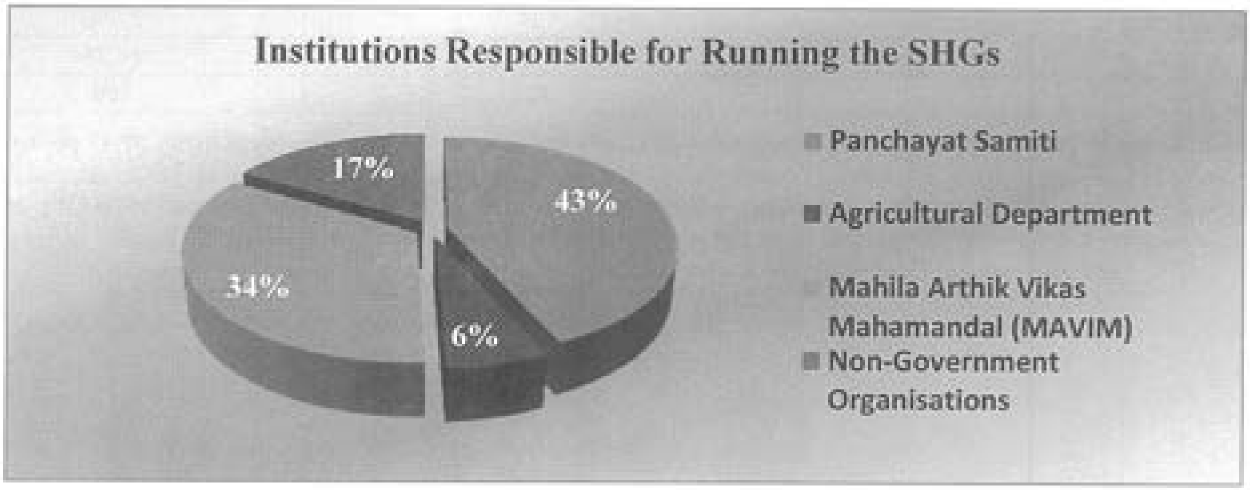

Fig. 1 : Institutions Responsible for Running the SHGs

Hence, on the basis of the results, it is concluded that significantly high percentage (Since, the calculated Chi-Square value is higher than the tabular value at $P<0.05$) of the SHGs are run by the Panchayat Samitis.

Institutional Support Received by SHGs

Institutions are the crucial and unavoidable foundation upon which society develops and grow. The Government of India has setup various institutions to promote Women/SHG entrepreneurial activities. During planning era a number of institutions were established for the development of women entrepreneurship. In rural area for alleviation of poverty concept of development of entrepreneurship through women self help groups were implemented by government and self help group promoting institutions (SHGPI) namely District Rural Development agencies (DRDA) with active involvement of Panchayat Raj Institutions (PRIs), Line departments like department of Agriculture, Animal Husbandary, Sericulture, Horticulture, District Industries Centre (DIC), Khadi and Village Industries , Maharashtra Industrial and Technical Consultancy Organization (MITCON), women and child development, Nationalized bank, National Bank for Agriculture and rural development (NABARD), District Co-operative bank and NGOs together launched many programs for the growth of SHG entrepreneurship to motivate them in establishing new enterprises and to upgrade and develop the existing one. These Institutions render assistance to women SHG entrepreneur by providing them legal guidance counseling, training, financial, technological and marketing assistance etc. in view of this the data about institutional support and type of assistance received by SHG in study area is presented in table below.

Table 3 : Institutional Service/Support Received by SHG Entrepreneur

Service /Support received	Respondents	Per cent
No	28	18.7
Yes	122	81.3
Total	**150**	**100.0**

Table 3. indicates that 81.3 per cent SHGs informed that the SHGs of the area are benefitted and have received support from the institutions. While 18.7 per cent reported that they have not availed benefits from such institutions, primarily because, they were not aware of different schemes and credit facilities offered by these institutions as part of the Govt. schemes.

Thus, it is concluded that majority of SHGs of the region have been benefitted and received services from the Institutions.

Institutions Supporting to SHG Enterprises

Following table shows the type of institutional support received by the SHGs in view of the entrepreneurship development in the region. For this aspect only 122 respondents provided information, who were the actual beneficiaries of various schemes offered by the institutions.

Table 4 : Institutions Supporting SHG Entrepreneurs

Institutions	Respondents	Per cent
Government	70	57.37
Non-Government	34	27.86
Both	18	14.75
Total	**122**	**100**

Table 4: shows that among the institutions assisting SHG entrepreneurs to develop entrepreneurship 57.37 per cent SHGs received benefit and support from government organizations like DRDA, Panchyat Samiti, MAVIM, MITCON etc and 27.86 per cent SHGs received support from Non-government organizations, like Bhartiya Agro Industries Foundation (BAIF), Mitra etc. working in study area. However14.75 per cent respondents received support from both the organizations. (**Fig.2**).

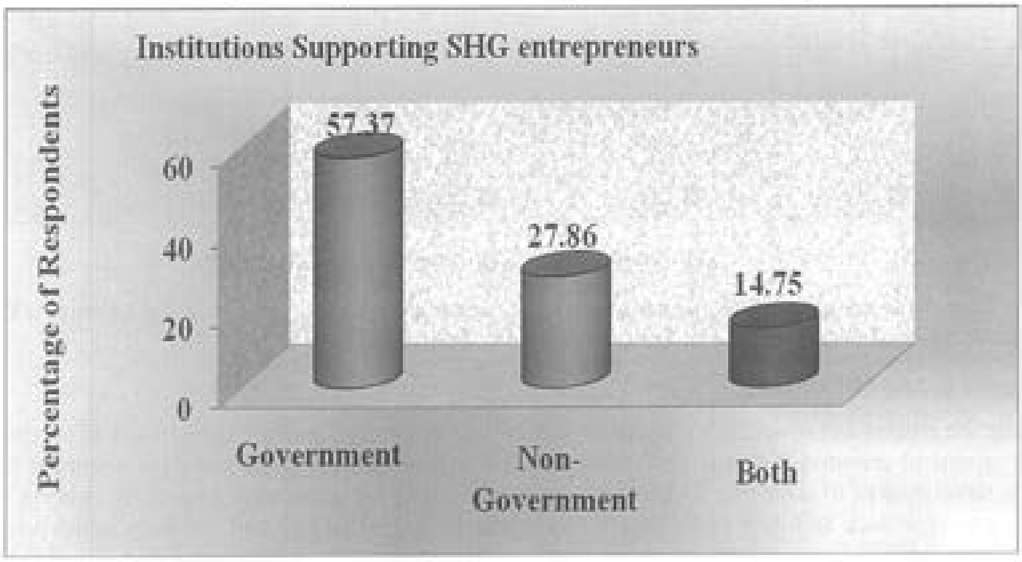

Fig. 2 : Institutions Supporting SHG Entrepreneurs

The results indicate that the Government institutions are more involved in SHC entrepreneurship development than non-government organization in region.

The support offered by the various institutes is very important for sustainable development of the SHGs. Parab (2014) has stated that the failure of institutions involved in developing women entrepreneurs needs to be studied in greater details with a case study approach. Institutions should also lay more emphasis in providing quality improvement through the adoption of latest technology and utilization of modern human resource management practices in imparting necessary training to sample women entrepreneurs.

Inputs for the Enterprise Activity – Government's Share

The State and Central Governments are the primary sources of the help (in different forms) for the successful operation of the SHGs. The inputs contributed by the Govt. projects like Swarnajayanti Gramin Swayamrojzar Yojana, Livelihood Project, Tejeswini project, and National Rural livelihood projects etc. play a constructive role in the betterment of the SHGs in general and the socio-economic status of the women of rural area in particular.

Table 5 : The Inputs Contributed by the Govt. Project in Enterprise Activity

Percentage of Input shared by Govt.	Respondents	Per cent	
Nil	65	43.3	Chi Square= 141.4 P=<0.05
1 to 25 Per cent	2	1.3	
25 to 50 Per cent	66	44.0	
50 to 75 Per cent	11	7.3	
Above 75 Per cent	6	4.0	
Total	**150**	**100.0**	

Above **Table 5** indicates data pertaining to the details of inputs contributed through various government initiatives or project aimed at improving enterprise activity in the study area. The table indicates that the 44.0 per cent SHGs have received up to 25 to 50 per cent of the total cost from the Govt. projects for the enterprise activity, while 43.3per cent have received nothing from the Govt. projects. However, 7.3, 4.0 and 1.3 per cent SHGs have received 50 to75 per cent, above 75 per cent and 1 to 25 per cent inputs respectively for the enterprise activities (**Fig.3**). The lack of sharing SHG enterprise activities by government projects can be attributed to the facts that SHG are not aware about government schemes and benefits.

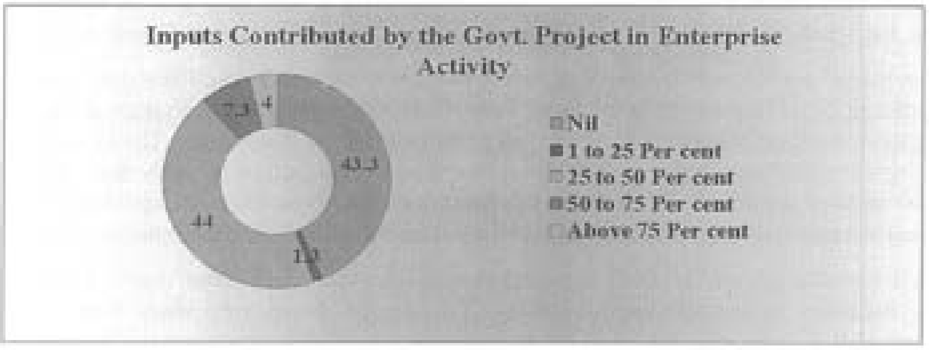

Fig. 3 : Inputs Contributed by the Govt. Project in Enterprise Activity

Thus, it is concluded that majority ($P<0.05$) of the SHGs of region have received 25 to 50 Per cent of the input from the Govt. projects to undertake the enterprise activity.

Type of Assistance Received by SHG

Following table shows the types of support availed by SHGs from the Institutions, where the nature of assistance is like financial, training and skill development, procurement of raw material, infrastructure, marketing and technological assistance.

Table 6 : Assistance Received by Self Help Group Entrepreneurs

Type of assistance received by SHG	Yes		No		Total
	No.	Per.	No.	Per.	
Financial Assistance	94	77.0	28	23	122
Technical training & skill development	98	80.3	24	19.7	122
Procurement of raw material	40	32.8	82	67.2	122
Physical infrastructure	7	5.7	115	94.3	122
Marketing & technological assistance	43	35.2	79	64.8	122

Above **Table 6** indicates that 80.3per cent SHGs have received technical training & skill development assistance which is related to enterprise. Followed by 77 per cent SHG who received financial assistance in the form of government subsidies under different schemes for starting enterprises. Physical infrastructure assistance were received to negligible (5.7 per cent) of SHGs.(**Fig.4**)

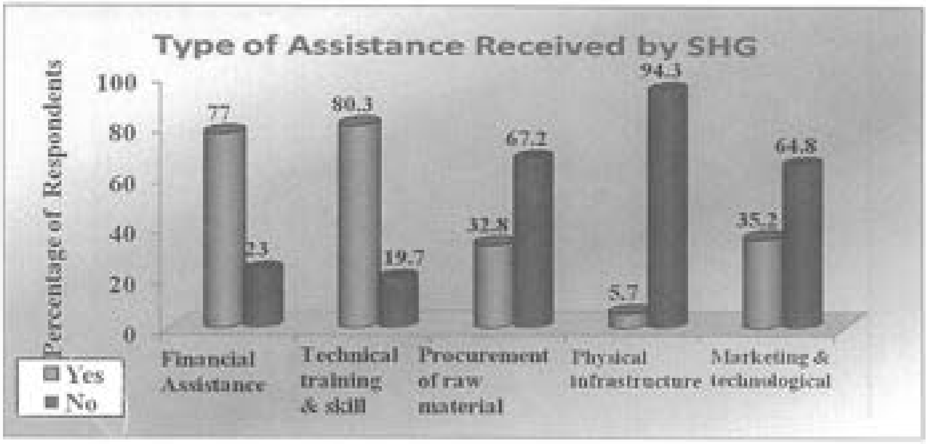

Fig. 4 : Assistance Received by Self Help Group Entrepreneurs

Thus, it is evident from the study results that most of the SHGs of study area have received financial and technical training and skill development related assistance.

Summary & Conclusion

On the basis of research results, in view of investigator it can be concluded that, significantly ($P<0.05$) high (37) number of enterprises undertaken by SHG women is based on service providing activities like, grocery shop, cloth shop, bangles shop, stitching and tailoring, bags making, pottery, tea selling, operating mess service, anganwadi meal service etc.

Significantly high percentage 43.3 ($P<0.05$) of the SHGs in the area are run by the Panchayat Samitis. Majority of the SHGs (66) of region have received 25 to 50 per cent of the input from the Govt. projects to undertake the enterprise activity. Majority of SHGs (122) of the region have been benefitted and received services from the institutions. The Government institutions are more involved in SHG entrepreneurship development than non-government organisation in study area. Regarding type of assistance received by SHGs that most of the SHGs (94 and 98) of region have received financial assistance in the form of government subsidies under different schemes and assistance support, technical training and skill development from respective institutions.

Though there is a positive growth of SHG entrepreneurship but more and more motivation is required to increase the involvement of SHG members in entrepreneurial activity. To manage group enterprises more improvement is needed in development of managerial ability, administrative skills, good leadership, conflict management, marketing skills, account-keeping and information of legal aspects in SHG members by development of more focused and skill oriented training programs. As well long duration vocational training program needed to enhance the entrepreneurship among the SHG members.

Suggestions and Recommendations

- It is suggested that regular monitoring of the activities of SHGs should be carried out so that the pace of up-liftment of the women and weaker sections can be increased.
- The SHG members should be made aware of the new schemes floated by the State and Central Government regarding the SHGs
- The SHGs should be encouraged to use the new communication technologies like, mobile phones, internet, etc. for executing their enterprise related works.
- Carefully crafted training programs should be developed for continuous improvement of the SHGs.
- The role of trainers, advisors, bankers in the growth of SHG member's entrepreneurial development should be studied in more details.

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Economic Analysis of Marketing of Jamun (Syzygiumcuminni L.) in Gadchiroli District of Vidarbha

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Abstract: Jamun (Syzygiumcumini L.) a member of the family myrtaceae is a popular indigenous fruit of India. It has got very valuable place in Auyurvedicmedicines. The Jamun is an important indigenous minor fruit of commercial value. Marketing plays a key role in post-harvest operation of fruits. The existing fruit trade is characterized by high transportation, grading, packing cost and lack of storage facilities etc. The Jamun fruits from Gadchiroli district are sent to different markets namely Chandrapur, Rajangaon, Raipur and Hyderabadad. Therefore, the present study has undertaken to study the marketing practices of Jamun. In order to fulfil the objective of study, necessary primary data on marketing cost of Jamun growers were collected from the sample growers by the personal interview method using a structured schedule. In addition to this information on marketing cost i.e. transportation, grading, packing and market margin were collected from 10 market functionaries by the personal interview method using a structured schedule. The data collected pertains to the agricultural year 2019. The study concluded that the present marketing system of Jamun in study area was not perfect in nature. Few market middlemen dominated the market and producer have less control in fixing the price of their produce. Due to improper marketing functions like grading and standardization of Jamun fruits, absence of sufficient market information and market intelligence etc. producers often are exploited by the traders, which reduces the producer's share in consumer price. Due to lack of infrastructure, market information and knowledge of marketing practices producers are not able to approach distant markets to sell their produce.

Keywords: Marketing Channels, Price Spread, Marketing cost and Efficiency.

Introduction

Jamun (Syzygiumcumini L.) a member of the family myrtaceae is a popular indigenous fruit of India. It has got very valuable place in Auyurvedic medicines. But in India its organised orcharding is still lacking mainly because of proper information on cultivation practices and non-availability of dwarf and high yielding varieties.

The Jamun is an important indigenous minor fruit of commercial value. The original home of Jamun is India or the East Indies. It is also found in Thailand, Philippines, Madagascar and some other countries. In India the maximum number of Jamun trees are found scattered throughout the tropical and subtropical regions. It is widely grown in the larger parts of India from the Indo-Gangetic plains in the north to Tamil Nadu in the south. India ranks 2nd in production of Jamun in the world. In India Maharashtra is major Jamun producer followed by Uttar Pradesh, Tamil Nadu, Gujrat, Assam and others.

The post-harvest management of the Jamun fruit for long distance market is a difficult proposition as it is a climacteric fruit having fragile physical status. Marketing plays a key role in post-harvest operation of fruits. The existing fruit trade is characterized by high transportation, grading, packing cost and lack of storage facilities etc. The objectionable feature of the marketing system is the existence of long chain of middlemen which reduces the share of Jamun growers in the price paid by consumers. The producers are scattered over the wider areas. There is lack of any collective organisation among the producers, while fruit merchants, commission agents and retailers are well organised. The Jamun fruits from Gadchiroli district are sent to different markets namely Chandrapur, Rajangaon, Raipur and Hyderabadad. Therefore, the present study has undertaken to study the marketing practices of Jamun.

Materials and Method

In present study, multistage sampling procedure was followed for selection of Jamun growers which included study area as a primary unit, villages as secondary unit and Jamun growers as an ultimate unit. In Gadchiroli district Jamun production is concentrated in korchitahasil. Therefore, this tahasil was selected purposively as the study area. Out of 128 villages comes under korchitahasil, Jamun production is concentrated in about 35 villages. From these 35 villages, 5 villages were selected randomly to study the marketing aspect of Jamun growers. From each village 15 farmers were selected randomly. Thus, the final sample comprised of 75 Jamun growers from 5 villages of Korchitahasil.

In order to fulfil the objective of study, necessary primary data on marketing cost of Jamun growers were collected from the sample growers by the personal interview method using a structured schedule. In addition to this information on marketing cost i.e. transportation, grading, packing and market margin were collected from 10 market functionaries by the personal interview method using a structured schedule. The data collected pertains to the agricultural year 2019.

Tools of Analysis

Economics of Marketing of Jamun

Cost incurred for the marketing of Jamun by growers and market functionaries on harvesting, i.e. transport, grading, packaging etc. was worked out with the help of following formula.

$$MC = Cf + \sum Ci$$

Where, MC = Total cost of marketing; Cf = Cost incurred by farmer; Ci = Cost incurred by ith intermediary

The market margin of all the market intermediaries was estimated by using following formula:

$$TM = \sum (Pri - (Ppi + Cmi)$$

Where, TM = Total market margin; Pri = Sale price of ith intermediary; Ppi = Purchase price of ith intermediary; Cmi = Cost incurred by ith intermediaries

The marketing efficiency of identified marketing channels were worked out by using Acharya's formula (Acharya and Agarwal, 2004) i.e. ratio approach.

$$MME = FP \div (MC + MM)$$

Where, MME = Modified measure of marketing efficiency; FP = Price received by the grower; MC = Total marketing cost; MM = Net marketing margins.

Results and Discussion

Disposal of Jamun fruits

The disposal of Jamun fruits collected by the sample growers is given in Table1. It is seen from Table 1 that per farm yield of Jamun fruits was 32.50 qtls. Out of which 0.37 qtl was kept for family consumption, the loss at farm level was 0.63 qtl and remaining 31.50 quintals was sold in the market. It means maximum quantities (96.93%) were sold. This whole analysis of disposal pattern indicated that, in study area more than 95 per cent of Jamun fruits were observed as marketable surplus.

Table 1 : Per farm disposal of Jamun fruits (Quantity in quintal)

Sr. No.	Particulars	Overall (N-75)
1.	Total production	32.50 (100.00)
2.	Family consumption	0.37 (1.14)
3.	Loss at farm level	0.63 (1.94)
4.	Marketable surplus	31.50 (96.93)

Note - Figure in the parentheses indicate percentage to sample respondent.

Marketing channels for Jamun fruits

It was observed that in the movement of Jamun fruits from Jamun growers to ultimate consumers, village traders, commission agents, wholesaler, retailers/hawkers were involved as intermediaries. With these intermediaries the commodity passes through three different channels as prescribed below.

Channel-I Producer – Consumer

Channel-II Producer – Village trader- Commission agent/Wholesaler-Retailer/Hawker-consumer

Channel-III Producer – Commission agent/Wholesaler-Retailer/Processor/Hawker-consumer

The information about marketing channels prevailing in the study area for Jamun and quantity of produce marketed through various channels is presented in Table 3.

Table 2 : Channelwise frequency distribution of Jamun growers and quantity marketed through various channels

Sr. No.	Channels of Marketing	No. of Growers	Total quntity Marketed (Quintal)
1.	Channel-I	6 (8.02)	4.80 (0.19)
2.	Channel-II	60 (79.99)	1642.70 (67.39)
3.	Channel-III	9 (11.99)	790.00 (32.42)
Total		75 (100.00)	2437.50 (100.00)

It is observed from Table 3 that maximum numbers of growers (60) were using Channel-II for marketing of their produce, whereas the numbers of Jamun growers using Channel-I and Channel-III were 6 and 9 respectively. Regarding quantity marketed, it was observed that, maximum proportion of total quantity (67.39%) passed through Channel-II followed by 32.42 per cent through Channel-III and remaining 0.19 per cent passed through Channel-I. The analysis concluded that, on the basis of number of growers and quantity handled Channel-II was the most popular channel in the study area, indicating the necessity of services of intermediaries in marketing of Jamun.

Table 3 : Cost of Jamun incurred in different channels of sale (Figures in Rs. Per quintal)

Sr. No.	Item of cost	Channels		
		I	II	III
1.	Labour cost for harvesting, assembling, grading and packing	362 (83.41)	392 (40.84)	378 (62.37)
2.	Cost of packing	40 (9.22)	120 (12.49)	80 (13.21)
3.	Cost of transport	20 (4.61)	90 (9.38)	60 (9.90)
4.	Market charges	-	300 (31.26)	70 (11.55)
5.	Rent of building and miscellaneous expenses	-	10 (1.04)	-
6.	Loss at farm level and in transport	12 (2.76)	48 (4.99)	18 (2.97)
	Total	434 (100.00)	960 (100.00)	606 (100.00)

The marketing cost incurred by the various agencies in different channels on harvesting, assembling, transport, grading and other miscellaneous were computed and are given in Table 3.

In study area no Jamun growers found to follow any cultivation practices in Jamun production. Only harvesting of fruits is done with the help of human labours and the cost of labour utilized for harvesting of fruits was considered under marketing as labour cost.

It is seen from Table 3 that the per quintal cost of marketing was highest in Channel II (Rs.960) followed by Channel III (Rs.606). The per quintal marketing cost in Channel I was lowest i.e. (Rs.434) because of direct chanel. Out of the total marketing cost highest share were found for labour cost. The cost of packaging was maximum in Channel-II (Rs.120) followed by Channel III (Rs.80) and Channel-I (Rs.40). The containers used in all the channels were plastic crates. But the quality and price of plastic crates varied in study area. This accounted for variation in the packaging cost. The transportation cost was highest in Channel-II because the intermidiatiries involved in this channel were sending the Jamun to distant markets. The looses of fruits in the process of marketing is indirect one and has to borne by the market intermediaries. Therefore, the cost due to fruit loss was considered as marketing cost. This cost varied between 2.76 per cent to 4.99 per cent in different channels. The highest loss at farm level and in transport was found in Channel-II, was due to transportation shocks and large handling of the produce. On the basis of per quintal cost of marketing incurred on various marketing channels of trade, it could be infered that, Channel-I was the most efficient one and Channel-III was the least efficient among the channels of Jamun trade in the present study.

Price spread in marketing of jamun

The price spread referes to the difference between the price paid by the consumer and the price received by the producer for an equivalent quantity of farm produce. This spread consists of marketing cost and marketing margins of the intermediaries, which ultimately determine the overall effectiveness of market system. The price spread studies can be helpful in studing the efficiency of the marketing system.The channelwise price spread in marketing of Jamun was worked out and the information of the same is presented in Table 4.

It is revealed from Table 4 that the per quintal price received by growers were different from channel to channel. In channel I highest price received to the producer because it is the direct channel. Very less quantity is dispossed through this channel. The highest price paid by consumer in channelI because it was a distant market.

Table 4 : Per quintal price spread in marketing of Jamun (Figure in Rs/quintal)

Sr. No.	Particulars	Channels		
		I	II	III
1.	Net price received by producer	5566 (92.76)	1260 (15.25)	3400 (43.60)
2.	Net margin of village trader	–	1820 (22.03)	–
3.	Net margin of commission agents	–	497 (6.02)	300 (3.85)
4.	Net margin of Wholeseller	–	1190 (14.41)	1020 (13.08)
5.	Net margin of retaile/hawkers	–	2535 (30.68)	2472 (31.70)
6.	Total cost of marketing	434 (7.24)	960 (11.62)	606 (7.77)
7.	Total marketing margin	–	6042 (73.13)	3792 (48.63)
8.	Consumers price	6000 (100.00)	8262 (100.00)	7798 (100.00)

Share of producer in consumer's price

Table 5 : Spread of consumer's price in percentage term (Fig.in percentage)

Sr. No.	Particulars	Channels		
		I	II	III
1.	Producer's share	**92.76**	**15.25**	**43.60**
2.	Marketing cost	7.24	11.62	7.77
3.	Marketing margin	-	73.13	48.63
4.	Consumer's price	100	100	100

The producer's share in consumer rupee was the highest in Channel-I (92.76%) followed by Channel-III (43.60%) and Channel-II (15.25%). The producer's share in consumer rupee in channel-I was highest because of producers directly sold their produce to consumers. The producers share in consumer rupee was more in Channel-III than Channel-II because producer's sale their produce to whole sellers through commission agents and bypassing the village traders.

Marketing efficiency

There are three approaches for measuring the marketing efficiency, they are Conventional approach, Shephard's method and Acharya's method. Out of these three, Acharya's method is the recent one given by Dr.S.S.Acharya. The same method was employed for measuring the marketing efficiency of each channel. The results of marketing efficiency are presented in Table 6.

It is observed from Table 6 that the marketing efficiency was much higher in Channel-III (1: 0.77) than that of Channel-II (1:0.18). The higher marketing margins in Channel-II resulted in poor efficiency of this Channel.

Thus, the analysis indicated that marketing of Jamun growers through commission agents to whole sellers was effective in study area.

Table 6 : Marketing efficiency of identified channels

Sr. No.	Particulars	Channels	
		II	III
1.	Net price received by the grower	1260	3400
2.	Total marketing cost	960	606
3.	Total marketing margin	6042	3792
	Marketing efficiency (ratio)	**1:0.18**	**1:0.77**

Conclusion

The study concluded that the present marketing system of Jamun in study area was not perfect in nature. Few market middlemen dominated the market and producer have less control in fixing the price of their produce. Due to improper marketing functions like grading and standardization of Jamun fruits, absence of sufficient market information and market intelligence etc. producers often are exploited by the traders, which reduces the producer's share in consumer price. Due to lack of infrastructure, market information and knowledge of marketing practices producers are not able to approach distant markets to sell their produce.

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Influence of Different Sowing Windows on Yield Contributing Characters of Soybean

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Abstract: A field experiment entitled "Influence of Different Sowing Windows on Yield Contributing Characters of Soybean" was conducted during Kharif 2019 on field of Department of Agril. Botany Dr. PDKV Akola. The trial was laid out in RBD design with three replication and nine dates of sowing at every week after the onset of monsoon with variety JS-335 to estimate the effect of sowing windows on growth, yield and it's component characters. The findings of the experiment revealed that the field performance parameters viz., days to 50% flowering, plant height and days to maturity were significantly influenced by dates of sowing. The early sowing in July 4^{th} week (T1) required maximum days (40.66 days) for 50% flowering. Days required for maturity goes on decreasing with delay in sowing i.e. 95.33 days in treatment T1 to 80.33 days in treatment T9. Plant height was significantly influenced by sowing dates. The early sowings shows increase in plant height whereas delayed in sowing reduces the plant height. The yield performing characters such as number of pods plant^{-1}, seed index, seed yield plant^{-1}, seed yield plot^{-1} and yield ha^{-1} of early sowings was significantly superior to late sowings. The sowing at second week on onset of monsoon i.e. 1^{st} week of July shows superior performance than rest of the sowings. The sowing at first week of July shows maximum number of pods plant^{-1} (66.9), seed index (11.64), seed yield plant^{-1} (13.45 g), seed yield plot^{-1} (4.03 kg) and yield ha^{-1} (29.88 qt). The least performance was shown at August 4^{rd} week sowing (T9).

Keywords: Soybean, sowing date, Yield, days to flowering, plant height, number of pods.

Introduction

Soybean is native of Eastern Asia. The crop has been recently introduced in India and is considered both pulse as well as oilseed crop. India is the fifth largest producer of soybean in the world after USA, Brazil, China and Argentina. The United States of America is the largest producer, contributing 32% of the world's soybean production. Soybean (*Glycine max* L.) popularly known as "Golden bean" Soja bean, Soya bean, Chinese pea and Manchurian bean which belongs to family Leguminaceae, sub family fabaceae and genus glycine is one of the most important oil seed crop known for its excellent protein (42-45%), oil (22%) and starch content (21%). The crop is one of the likely solutions for overcoming the world's protein hunger and a good source of vitamin B complex, particularly thiamine and riboflavin. Soybean protein is rich in valuable amino acids like lysine (5%) in which, most of the cereals are deficient. In India, it is grown in an area of 12 M ha with a production of 9.30 mmt and productivity of 0.78 t ha^{-1} in 2019. In India, major soybean growing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh and Andhra Pradesh. In Maharashtra, total area under cultivation is 3.73 M ha in Kharif season 2019 with production of 3.94 mmt and productivity of 1.05 t ha^{-1}. There are many factors limiting soybean production at farm. Among the agronomic practices sowing date has remarkable influence on soybean yield. However, the effect of sowing date on soybean grain yield depends on genetic and environmental conditions, sowing date is an important factor affecting soybean growth, development, seed yield and quality. Sowing date is the most important factor that impacts soybean seed yield. The optimum time of sowing, enables favorable environmental conditions for growth and seed yield. Generally, the sowing date varies depending on the climatic condition of the region and the varieties to be grown. Thus the sowing of soybean varieties of high yield potential at optimum sowing time is considered as a hopeful approach to increase soybean production.

Material and Methods

The present investigation initiated "Influence of Different Sowing Windows on Yield Contributing Characters of Soybean" was conducted during Kharif-2019 at field of Department of Agril. Botany, Dr. PDKV, Akola. This study included Soybean Var. JS-335. Total nine sowing date starting from onset of monsoon having one week interval with three replications of Soybean is tested in Randomized Block Design. The recommended cultural practices were followed to raise a good and healthy crop. The sowing is done by dibbling method with spacing of 45x10 cm spacing.All the observations were recorded on randomly selected plants in each replication and the mean values were considered for statistical analysis.

Result and Discussion

PLANT HEIGHT (cm)

The present study revealed that sowing dates had significant impact on plant height at 30, 60, 90 days after sowing (DAS) (Table 1). An increased trend of plant height was observed in the sowings from June 4th week (T1) to August 4th week (T9) and thereafter plant height was decreased with delay in sowing. This trait was ranged from 30.54 to 51.31 cm with grand mean of 42.99 cm at 90 DAS. Tallest plants were observed from July 1st week (T2) sowing at 30, 60 and 90 DAS (23.23, 39.94, 51.31cm respectively) followed by June 4th week sowing (T1) (22.9, 36.76 and 49.80cm respectively) and were statistically on par with each other at 60 and 90 DAS. Minimum plant height was recorded from August 4th week (T9) sowing at 30, 60 and 90 DAS (14.76, 23.13 and 30.54 cm respectively). Taller plants during July 1st week (T2) sowing might be due to the favorable environmental factors viz, rainfall, bright sunshine hours, optimum mean temperature and relative humidity during its growth period and these factors might have favorably influenced the cell division, cell elongation and increased internodal length resulting in taller plants. The significant decrease in plant height due to delayed sowing can be associated with lower minimum temperature and huge differences between maximum and minimum temperature that the plants at the seventh and eighth sowing dates were experienced as a result vegetative growth was restricted leading to early maturity of plants. Thus, the plants did not have adequate opportunity for photosynthesis and translocation of food materials to the sink and as a result their height was decreased. These findings are in close conformity with the Ahmed *et al.* (2010) who reported that late sowings of soybean resulted in plant height reduction. Also supported by Bateman *et al.* (2020), Kanade *et al.* (2019) and Chavan *et al.* (2018).

Table 1 : Effect of Sowing Windows on Yield and yield contributing characters in soybean

Treatments	30 DAS (cm)	60 DAS (cm)	90 DAS (cm)	No. of Pods plant^{-1}	Yield plant^{-1} (gms)	Yield Plot^{-1} (kg)	Yield ha^{-1} (qtl)	seed Index (gms)
T1	22.9	36.76	49.80	56.33	10.97	3.29	24.38	10.33
T2	23.23	39.94	51.31	66.9	13.45	4.03	29.88	11.64
T3	21.26	34.52	46.55	46.36	10.7	3.21	23.77	10.27
T4	19.46	32.34	46.51	37.70	8.98	2.69	19.97	9.05
T5	18.9	28.99	44.89	31.86	7.71	2.31	17.13	9.40
T6	16.40	27.45	43.43	28.13	5.64	1.69	12.54	8.33
T7	16.76	24.60	40.24	25.6	3.18	0.95	7.06	7.60
T8	15.23	23.33	33.69	23.5	2.60	0.78	5.78	7.15
T9	14.76	23.13	30.54	21.43	2.75	0.82	6.11	7.08
Mean	**18.77**	**30.12**	**42.99**	**37.53**	**7.33**	**2.20**	**16.29**	**8.98**
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	**0.71**	**0.86**	**0.90**	**1.06**	**0.22**	**0.06**	**0.50**	**0.25**
CD at 5%	**2.14**	36.76	**2.72**	**3.19**	**0.678**	**0.20**	**1.50**	**0.77**

NUMBER OF PODS PLANT^{-1}

Number of pods plant^{-1} has an important and direct yield contributing component. Number of pods plant^{-1} varied significantly among treatments and ranged from 21.43 to 66.90 (Table 2). The highest number of pods plant^{-1} (66.90) was recorded from July 1st week (T1) sowing followed by June 4th week (T2) sowing (56.3) and were statistically significant over all other treatments (Table 1). Lowest number of pods plant^{-1} (21.43) was produced by August 4th week (T9) sowing. Number of pods plant^{-1} decreased as sowing date was delayed from June to August. The present finding is supported by Sikka *et al.* (2017) who reported that there was a substantial reduction in number of pods plant^{-1} with late sowing. Earlier sowing probably had more period for vegetative and reproductive growth compared to later dates of sowing which had smaller vegetative and reproductive period causing reduction in growth and development and ultimately produced smaller number of pods plant^{-1}.

SEED YIELD PLANT^{-1}(g)

Date of sowing significantly influenced the seed yield per plant. This trait recorded general mean value of 7.33 g with a range of 2.75 to 13.45 g (Table 1). Sowing in July 1st week (T2) recorded significantly higher seed yield per plant (13.45 g), followed by June 4th week (T1) sowing (10.97 g) and July 2nd week (T3) sowing (10.7 g). June 1st week sowing showed superiority in seed yield plant^{-1} by the production of greater number of pods plant^{-1}(66.9) and bolder seed. Minimum seed yield plant^{-1}(2.75 g) was obtained from August 3rd week (T8) sowing. This might be due to production of lower number of pods plant^{-1}(21.43) with smaller seed size. High temperatures (>30°C) at reproductive stage might have affected pollination, fertilization and consequently poor pod set resulting in lower number of pods per plant (Chen and Wiatrak, 2010). The present finding is supported by Elmore (1990) who reported that there was a substantial reduction in number of pods plant^{-1} with late sowings. Earlier sowing probably had more period for vegetative and reproductive growth compared to later dates of sowing which had smaller vegetative and reproductive period causing reduction in growth and development and ultimately produced smaller number of pods plant^{-1}. Also these findings were supported by Madhavi *et al.* (2000) and Kumar *et al.* (2018) who reported that seed yield plant^{-1}decreased with delay in sowing date due to lack of sufficient vegetative growth, lower number of pods plant^{-1} and reduced seed weight and ultimately resulted in lower seed yield of plant. Also Pierozan *et al.* (2017) revealed that the grain yield plant^{-1} decreased with delay in sowing.

YIELD PER PLOT (Kg)

Different sowing dates have significant difference on yield per plot. The highest yield per plot is observed from July 1st week (T2) sowing (4.03Kg) and lowest at August 2nd week (T9) sowing (0.78Kg). The difference is due to good yield performance of plants in treatment T2 (July 1st week sowing) among another. Bold Seed, higher number of pods per plant and higher seed yield per plant resulted in increased seed yield per plot.

SEED YIELD (q ha^{-1})

Seed yield is a complex biological process affected by genetic potential and plant characteristics, management practices, soil and environmental conditions. Significant differences in seed yield was observed for the different sowing dates and this trait recorded a general mean value of 16.29 q ha^{-1} ranging from 6.11 to 29.88 q ha^{-1} (Table 1). Higher seed yield (29.88 q ha^{-1}) was recorded in July 1st week (T2) sowing followed by June 4th week sowing (24.38 q ha^{-1}). The lowest yield is observed in August 3rd week (T8) sowing (5.78 q ha^{-1}). Significantly higher yield from July 1st week sowing was realized due to enhanced expression of yield attributing characters such as higher number of pods plant^{-1} (66.9), seed yield per plant (13.45 g), test weight (11.64 g), bold seed size and optimum mean temperature during seed filling stage. Significant reduction in seed yield was observed when sowing date was delayed from June to August. Lower seed yield (6.11 q ha^{-1}) was recorded in August 3rd week sowing and this might be due to a shortened vegetative growth period and the reduction in number of pods per plant, seed yield per plant and seed index. The highest soybean seed yield obtained with early sowing was due to more favorable vegetative growth period resulting in more dry matter accumulation and also effective translocation of photosynthesis from source to sink during the reproductive phase. The yield reduction with delay in sowings of soybean might be due to a shortened vegetative period with decrease in plant height and dry matter accumulation leading to decrease in yield attributes and yield. The reduction in yield during late sowing can also be attributed due to higher differences in minimum and maximum temperatures temperature which prevailed leading to low biomass accumulation and low yield. The present results are also in accordance with those of Bateman *et al.* (2020), Madhavi *et al.* (2000), Nayak *et al.* (2020), Kalyan *et al.* (2017) and Radhakrishna Murthy *et al.* (2001).

SEED INDEX (g)

Seed index was significantly affected by sowing dates which was ranged from 11.64 to 7.08 g (Table 2). Higher 100 seed weight (11.64 g) was recorded for July 1st week (T2) sowing followed by June 4th (T1), July 2nd week (T3), July 4th week (T5), July 3rd week (T4) and were statistically on par with each other. Lowest seed index (7.08 g) was recorded for seeds from August 4th (T9) week sowing. The seed index significantly declined when sowing was delayed from June to August. The highest 100 seed weight recorded in July sowings might be due to optimum climate and sufficient time for growth and pod filling, which enabled the plants to produce bold seeds while, late sowings decreased the effective rate of pod filling and shortened the effective duration of pod filling compared with earlier sowings. Heat stress during seed development stage caused the poor seed development and reduced the seed size in soybean. Higher seed index recorded with early sowing might be due to favorable weather conditions coupled with more number of growing days during reproductive stage which might have helped in translocation of more assimilates into seeds and subsequently developed to bold seeds with early sowing. Results obtained are in accordance with Billore *et al.* (2000) and Halvankar *et al.* (2001).

Conclusion

In the present investigation of "Influence of Different Sowing Windows on Yield Contributing Characters of Soybean" concluded that the Soybean crop sown a week after onset of monsoon results in higher seed yield. A week after the onset of monsoon found to be optimum time for proper growth and development of the crop. The results need to be confirmed by continuing the experiment for one to two seasons.

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Productivity and Economics of Fodder Maize Varieties as Influenced by De-topping Practices and Nitrogen Levels

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Abstract: A field experiment entitled "Productivity and economics of fodder maize varieties as influenced by de-topping practices and nitrogen levels was conducted during *kharif* season of 2018 at Department of Agronomy, Dr. P.D.K.V., Akola The experiment was laid out in split plot design with three replications. Experimental results revealed that treatments no de-topping produced significantly greater yield attributes and grain yield ha^{-1} and monetary returns viz., gross, net returns and B : C ratio over de-topping treatment. Fodder yield ha^{-1} was maximum with variety African tall as compared to Pioneer-3296. However, yield attributes, grain yield ha^{-1}, gross and net monetary returns ha^{-1} and B:C ratio were recorded significantly maximum with variety Pioneer-3396 over African tall. Increased levels of nitrogen increased yield attributes, grain yield and monetary return was greater with application of 150 Kg N ha^{-1} as compared to application of 100 Kg N ha^{-1}, 50 Kg N ha^{-1} and control, respectively.

Introduction

Availability of green forage to animals is the key to success of dairy enterprise and it is difficult to maintain the health and milk production of the livestock without supply of the green fodder. Fodder maize (*Zea mays L.*) is one of the most important dual-purpose crops grown throughout year. Nitrogen is a primary nutrient required by crop plants for their growth and development. The application of nitrogen not only affects the forage yield of maize, but also improves its quality especially its protein contents. It is reported that application of nitrogen to maize increase fodder nutritive value by increasing crude protein and by reducing ash and fiber contents. Plant height, stem diameter, green fodder yield and protein, fiber, and total ash content were increased by increasing nitrogen levels. De-topping refers to nipping or the removal of terminal portion from the uppermost node to improve the yield through greater functioning of remaining leaves by arresting unnecessary growth, decreasing mutual shading of leaves, enhancing light interception, increasing nutrient uptake, decreasing competition between the tassel and cob for available plant nutrients, diverting plant nutrients to the reproductive part which aids in better source-sink relationship and better cob development. De-topping has the additional advantages of controlling lodging in case of excessive vegetative growth and provide green fodder to animals and without sacrificing the grain yield. Proper time of de-topping seems to be very important for controlling lodging and obtaining enough forage without sacrificing grain yield. Keeping in view the above consideration a field investigation entitled "Productivity and economics of fodder maize varieties as influenced by de-topping practices and nitrogen levels" planned with objective to influence of de-topping and maize varieties on productivity and economics of fodder maize.

Material and Methods

A field experiment entitled "Evaluation of fodder value of maize varieties as influenced by nitrogen levels and de-topping was conducted during *kharif* season of 2018 at Department of Agronomy, Dr. P.D.K.V., Akola The experiment was laid out in split plot design with three replications keeping four combination of two de-topping practice (D_1 : No de-topping and D_2 : De-topping after 15 days tasseling) and two varieties (V_1 : African tall and V_2 : Pioneer-3396) under main plot and four nitrogen levels (N_0- 0 Kg, N_1-50 Kg, N_2-100 Kg and N_3 - 150 Kg N ha^{-1}, respectively) under sub plot. The gross and net plot sizes were 3.6 X 4.0 m^2 and 3.0 X 3.6 m^2 respectively. Recommended dose of fertilizers i.e. N applied as per treatments in two split *i.e* 50% as basal dose and remaining 50 % at 30 after sowing days as top dressing and dose of 60:60 Kg/ha P and K is common to all treatments, respectively.

Results and Discussion

Effect of no de-topping and de-topping

Yield attributes viz., weight of cob (g), number of grains per cob were significantly influenced by no de-topping and de-topping treatment. Significantly maximum weight of cob (197.85 g) and number of grains (502.36) was recorded with no de-topping over the de-topping (Table 1). Significantly highest grain yield (Table 2) was recorded in (D_1) no de-topping (3923 Kg ha^{-1}) over (D_2) de-topping (3123 Kg ha^{-1}). However, treatment (D_2) de-topping (7339 Kg ha^{-1}) recorded significantly maximum fodder yield over (D_1) no de-topping (6096 Kg ha^{-1}). The findings are in accordance with those of Jalilian and Delkhoshi (2014). Significantly highest gross monetary return (Table 2) was obtained with (D_1) no de-topping Rs 90754 ha^{-1} over (D_2) de-topping Rs

84236 ha^{-1}. Significantly highest net monetary return was obtained with (D_1) no de-topping (Rs. 58868 ha^{-1}) over (D_2) de-topping (Rs. 50050 ha^{-1}).

Table 1 : Yield attributes viz., (Length of cob, weight of cob, girth of cob, number of grains, and test weight) of maize influenced by various treatments.

Treatments	Length of cob (cm)	Weight of cob (g)	Girth of cob (cm)	Number of grains/cob	100 seed weight (g)
Main plot					
A. De-topping					
D_1 : No de-topping	17.45	197.85	14.48	502.36	28.07
D_2 : De-topping	17.17	178.26	14.76	435.26	26.93
SE (m) ±	0.26	3.35	0.22	4.05	0.48
CD at 5 %	NS	11.56	NS	13.97	NS
B. Varieties					
V_1 : African tall	16.64	177.27	13.17	452.55	25.60
V_2 : Pioneer-3396	17.98	198.83	16.07	485.07	29.39
SE (m) ±	0.26	3.35	0.22	4.05	0.48
CD at 5 %	0.90	11.56	0.76	13.97	1.66
Sub plot					
C. N levels					
N_0 : 0 Kg ha^{-1}	15.36	173.57	14.33	371.52	26.13
N_1 : 50 Kg ha^{-1}	15.99	177.93	14.43	435.45	27.50
N_2 :100 Kg ha^{-1}	17.82	198.13	14.70	524.35	27.56
N_3 :150 Kg ha^{-1}	20.07	202.59	15.03	543.92	28.80
SE (m) ±	0.18	3.82	0.75	10.71	0.25
CD at 5 %	0.54	11.15	0.21	31.28	0.74
Interactions	**Interaction effects of D X V, D X N, V X N and D X V X N were found to be NS**				
GM	**17.31**	**188.05**	14.63	**468.81**	**27.49**

Table 2 : Grain, fodder, biological yield (Kg ha^{-1}) and gross, net monetary returns (Rs ha^{-1}) and benefit cost ratio of maize influenced by various treatments.

Treatments	Yield (Kg $^{ha-1}$)		Monetary returns (Rs ha^{-1})		B:C Ratio
	Grain	Fodder	Gross	Net	
Main plot					
A. De-topping					
D_1 : No de-topping	3923	6096	90754	58868	2.83
D_2 : De-topping	3123	7339	84236	50050	2.43
SE (m) ±	104	179	1529	1529	-
CD at 5 %	361	620	5280	5280	-
B. Varieties					
V_1 : African tall	2567	7518	74627	44491	2.48
V_2 : Pioneer-3396	4459	5917	100363	64427	2.78
SE (m) ±	104	179	1529	1529	-
CD at 5 %	361	620	5280	5280	-
Sub plot					
C. N levels					
N_0 : 0 Kg ha^{-1}	2510	5021	63592	31429	1.97
N_1 : 50 Kg ha^{-1}	3537	6588	87349	54603	2.66

Treatments	Yield (Kg $^{ha-1}$)		Monetary returns (Rs ha^{-1})		B:C Ratio
	Grain	Fodder	Gross	Net	
N_2 :100 Kg ha^{-1}	3931	7455	97543	64220	2.91
N_3 :150 Kg ha^{-1}	4074	7805	101497	67585	2.98
SE (m) ±	103		1720	1720	-
CD at 5 %	302	493	5024	5024	-
Interactions	**Interaction effects of D X V, D X N, V X N and D X V X N were found to be NS**				
GM	**3514**	**6718**	**87496**	**54460**	**2.63**

Effect of varieties

Yield attributes viz., length of cob, weight of cob, girth of cob, number of grains, and test weight were significantly influenced by the type of varieties. Significantly higher yield attributes was recorded with grain type variety (V_2) Pioneer-3396 over the fodder type variety (V_1) African tall (Table 1). Significantly highest grain yield was recorded with (V_2) Pioneer-3396 (4459 Kg ha^{-1}) over the (V_1) African tall (2567 Kg ha^{-1}). However, significantly highest fodder yield was recorded with (V_1) African tall (7518 Kg ha^{-1}) over the (V_2) Pioneer-3396 (5917 Kg ha^{-1}). The greater yield in grain type variety Pioneer-3396 might be due to high yield genetic potential as compared to fodder type variety which yields less is common phenomenon. Similar results were also reported by Massy and Gaur (2006) (Table 2). Significantly highest gross monetary return was recorded in (V_2) Pioneer-3396 (Rs. 100363 ha^{-1}) over the (V_1) African tall (Rs. 74627 Rs ha^{-1}). Significantly highest net monetary return was recorded in Pioneer-3396 (Rs. 64427 ha^{-1}) over African tall (Rs. 44491 ha^{-1}). Similar research trend was also found Massy and Gaur (2006). In case of varieties highest benefit cost ratio was registered with (V_2) Pioneer-3396 (2.78) over (V_1) African tall (2.43) (Table 2).

Effect of nitrogen levels

Yield attributes (Table 1) viz., length of cob (cm), weight of cob (g), girth of cob (cm), number of grains per cob and test weight (g) significantly influenced by application various nitrogen levels. Significantly greater yield attributes were recorded with application of nitrogen (N_3) @ 150 Kg N ha^{-1} over the (N_1) @ 50 Kg N ha^{-1} and (N_0) @ 0 Kg N ha^{-1}. However application of (N_3) @ 150 Kg ha^{-1} was at par with (N_2) @ 100 Kg N ha^{-1} in case of weight of cob and number of grains. Significantly lowest weight of cob and number of grains was recorded with application 0 Kg N ha^{-1} *i.e.* control treatment. Significantly highest grain and fodder yield was noticed in (N_3) @ 150 Kg N ha^{-1} (4074 and 7805 Kg ha^{-1}) over (N_1) @ 50 Kg N ha^{-1} (3537 and 6588Kg ha^{-1}), and (N_0) @ 0 Kg N ha^{-1} (2510 and 5021Kg ha^{-1}), respectively. Result showed that with increased levels of nitrogen increases grain yield of maize. Similar findings were also reported by Singh (2001) (Table 2). Significantly highest gross monetary return was recorded in (N_3) @ 150 Kg N ha^{-1} (Rs. 101497 ha^{-1}) over control treatments *i.e.* application of (N_1) @ 50 Kg N ha^{-1} (Rs. 87349 ha^{-1}) and (N_0) @ 0 Kg N ha^{-1} (Rs. 63592 ha^{-1}). Similar research trend was also found by Aashish *et al.* (2015). Significantly highest net monetary return was observed with application of (N_3) @ 150 Kg N ha^{-1} (67585 Rs ha^{-1}) over treatments (N_1) @ 50 Kg N ha^{-1} (Rs. 54603 ha^{-1}) and (N_0) @ 0 Kg N ha^{-1} (Rs. 31429 ha^{-1}), respectively. Highest benefit cost ratio was recorded with treatment application of 150 Kg N ha^{-1} (2.98) followed by treatments 100 Kg N ha^{-1} (2.91), 50 Kg N ha^{-1} (2.66) and control (1.97), respectively (Table 2).

Effect of interactions

The interaction effects among the no de-topping and de-topping practice, variety and various nitrogen levels on yield attributes, grain yield and fodder yield per ha gross and net monetary returns per ha was found to be non-significant (Table 1 and 2).

Conclusions

1. Treatment of no de-topping recorded significantly maximum grain yield, gross monetary returns per ha, net monetary returns per ha and minimum fodder yield per ha as compared to de-topping after 15 days of tasseling.
2. Among the grain and fodder type variety, Pioneer-3396 recorded significantly maximum grain yield, gross and net monetary returns per ha and minimum fodder yield per ha as compared to fodder variety African tall.
3. Graded levels of N fertilizer *i.e.*150 Kg N ha^{-1} recorded significantly maximum grain yield, fodder yield, gross and net monetary returns per ha, respectively as compared to lower levels of nitrogen *i.e.* 100, 50 and 0 Kg N ha^{-1}, respectively.

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Product Formulation and Storage Study of Blend Pineapple Juice With Carrot and Orange Fruit Juice

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Abstract: Juice pineapple (*Ananas Comosus* L), carrot (*Daucus Carota* L), and orange (*Citrus Sinensis* L) were optimized to a blended beverage which was stored for 10 days in glass bottles (200mL capacity) at refrigerated temperature. Process standardization, sensory analysis, physical analysis and storage were evaluated. Marginal changes in pH, total soluble solids (TSS), total solid content (TSC) were observed. Based on study, concluded that sensory evaluation of the juice sample T_3 at the first day with score of 8.25 (Like very much) and at the end of storage with 7.0 (Like Moderately) average score recorded by hedonic scale. Juice sample T_3 has variations in pH (4.11 to 4.41), Total Soluble Solid (11.58 to 12.5 °Brix) and Total Solid Content (7.40 %) measured during the storage time. Hence, pineapple juice blend with carrot and orange juice in proportion of (60:35:05) was most effective juice and formulation of mixed blend juice beverage is possible to satisfy consumer taste and preferences. The product was safe during 7-8 days of storage with superior acceptability.

Keywords: Blended Juice, Pineapple Juice, Carrot Juice, and Orange Juice.

Introduction

Fruits and vegetables are critical to good health, and certainly good for all age categories as it forms an important portion of a healthy diet. It has nutritional potential, which makes it effective for use in any infection and disease according to the traditional concept of Ayurveda. (Awsi *et al.*, 2012) Fruits can be consumed fresh or processed into various forms. Pineapple and its juice is the most popular product due to its fruity aroma, fragrance and flavour and is purportedly the most widely consumed fresh fruit in the world with production exceeding 17 million metric tons a year (FAOSTAT 2007). Fruit juice provides a notable amount of iron which produces healthy red blood cells to transport oxygen throughout the body. Citrus fruits and juices are also a good source of folic acid, vitamin B, thiamine and potassium (Nagy *et al.* 1993; Brown 2000). A daily glass of fruit juice supplies 20 % of daily iron needs of a person. Fruit juice is very important in improving the memory and concentration, reducing mental weakness and in curing the problem of heavy bleeding during menstruation (Anonymous, 2016).

Juice blending is one of the best methods to improve the nutritional quality of the juice. It can improve the vitamin and mineral content depending on the kind and quality of fruits and vegetables used (De Carvalho *et al.*, 2007). Apart from nutritional quality improvement, blended juice can be improved in its effects among the variables, thus it cannot depict the net effects of various parameters on the reaction rate. Moreover, one could think of a new product development through blending in the form of a natural health drink, which may also be served as an appetizer. Owing to this an attempt should be made to prepared the blended juice to optimized blend juice were pasteurized at 90°C for 25 sec get cooled and stored at refrigerated temperature 5°C for 10 days. The sensory parameters as well as physical parameter like TSS, pH and total solid content of blend fruit juice studies for a period of 10 days.

From the study point of view some major objectives of our project work are studied such as to study of process development of pineapple juice blend with carrot and orange juice, to study of sensory evaluation of prepared blend juice, to study of physical properties of refrigerated stored blend juice and to study the storage period under refrigerated condition.

Materials and Methods

Local variety of pineapple, carrot and orange fruits in which fully matured, freshly harvested materials were selected for project work procured from the local market of Dediapada, Gujarat. The project work was carried out in the Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Dediapada.

The pineapple, carrot and orange were cleaned with running tap water. Previously sterilized stainless still knife used to peel and remove the unwanted upper layer of the pineapple and cut in the small cubes of 3 to 5 g approximately. At the same time the orange fruits were peeled and seeds removed manually and get separated all the strips. The carrots were peeled after caring out the pretreatment of Sodium hydroxide (40 g/L) at 95°C on the electric coil for 1 min and then immediately washed out with the running tap water. Peeled carrots were followed by blanching process with pretreatment of citric acid solution (6 g/L) at 95°C for 5min then cooled in iced water to inactivate their endogenous enzymes and soften their tissues. At the end, pineapple and orange juice was extracted with the help of juice blender and carrots were sliced and ground with addition of distilled water 1:1 (v/w) and filtered by steel sieve and muslin cloth to get purely fresh juice of each fruit sample.

After the juice preparation of pineapple, orange and carrot individually were blended in standardized ratio as shown in table 1. Then after 10 g sugar and 0.6 g/L citric acid was added in all samples to follow standard process and then juice mixture was filtered through muslin cloth. Fruit juices were blended in different ratio 100:0:0, 80:15:05, 70:25:05, 60:35:05 and stored in the refrigerator to avoid the microbial activity resulting from the surrounding. After that the blended juice were pasteurized at 95 °C for 10 min. After cooling, sugar was added 35 g/kg for sweetness and the preservative such as citric acid 0.6 g/L used in each juice sample for increasing the shelf life at safe refrigerated storage.

Table 1 : Prepare Juice Blend as per following blending ratios

Sr. No.	Blending combination	Blending ratio	Treatment code
1	Pineapple : Carrot : Orange	100:00:00	T_0
2	Pineapple : Carrot : Orange	80:15:05	T_1
3	Pineapple : Carrot : Orange	70:25:05	T_2
4	Pineapple : Carrot : Orange	60:35:05	T_3

Results And Discussion

pH of blend juice: pH is nothing but the measurement of the hydrogen ion concentration of a solution. Solutions with a high concentration of hydrogen ions have a low pH and solutions with low concentrations of H+ ions have a high pH (AOAC 1985).

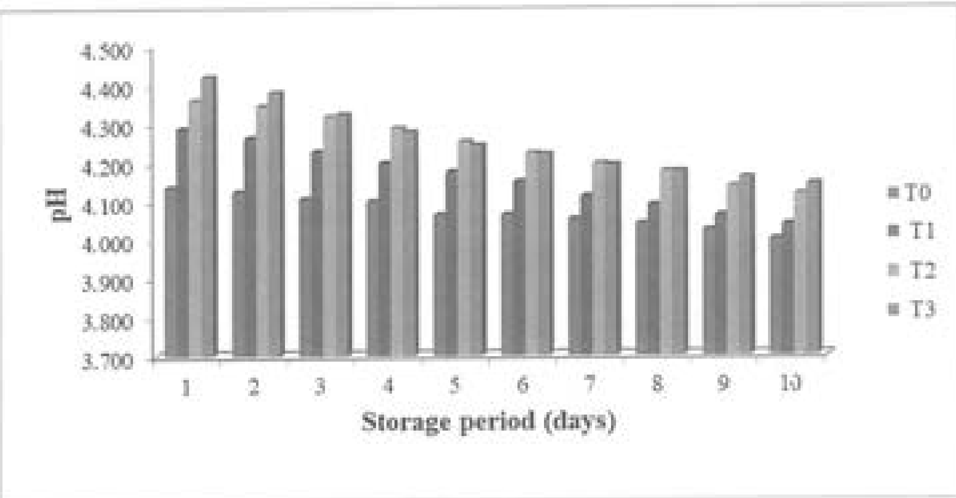

Fig. 1 : pH vs. storage period

Measurement of pH was carried out of each blended juice according the treatments given to the sample. The pH value ranges between 3.99 to 4.44, it was observed that the acidic nature of blend juice samples shown in fig 1. For treatment T0, Average pH value for first day was 4.13 and at the tenth day of storage the average pH value reduced up to 4.01. Similarly, the trend of gradual decrease in the pH values was shown for treatment T1, T2, T3 average pH value for first day was recorded 4.28, 4.36 and 4.42 at the tenth day of storage the average pH value reduced up to 4.03, 4.11 and 4.14 respectively. The sample of treatment T_3 was less acidic as compare with the other three samples due to its higher pH value. Sample T_3 was superior in pH as compare to Sample T_0, because less pineapple added in blend juice Sample T_3. Hence the acidic nature of the juice was maintained throughout the storage time.

Total Soluble Solid (TSS)

Sugar is the major soluble solids in fruit juice. Other soluble materials include organic and amino acids, soluble pectin's, etc. Soluble solids concentration (TSS%, °Brix) can be determined in a small sample of fruit juice using a digital refractometer. This instrument measures the refractive index, which indicates a light beam was "bent" when it passes through the fruit juice. Temperature of the juice was a very important factor in the accuracy of reading. All materials expand when heated and become less dense. For a sugar solution, the change is about 0.5% sugar for every 1°C. Good quality refract meter has a temperature compensation capability (Khurdiya, 1981).

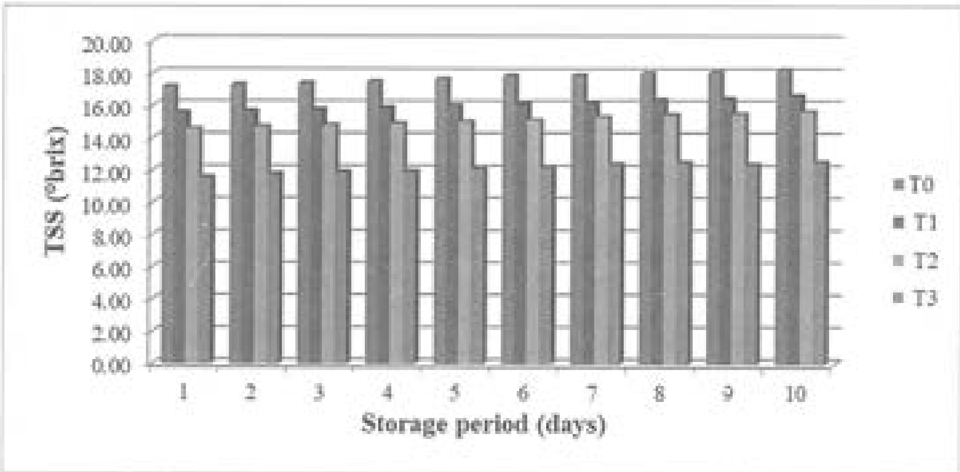

Fig. 2 : Total Soluble Solid vs. storage time

The TSS value indicates the sweetness of the product. The value ranges between 0-100°brix. The TSS measurement of blend juice in four replications of each treatment. The average TSS value ranges between 11.5–18.0°brix, shown in in Fig. 2. For treatment T0, Average TSS value for first day was recorded 17.2 and at the tenth day of storage the average TSS value increased up to 18.2. Similarly For treatment T1, T2, T3 average TSS value for first day was recorded 15.6, 14.6 and 11.6 at the tenth day of storage the average TSS value increased up to 16.6, 15.6 and 12.7 respectively.

Total Solid Content (TSC)

The method consists of measuring the total solid content of the food due to the evaporation of the water. Hot air oven drying method is generally used as they give accurate results. However this loss in weight may be measure of the water content of the sample and remained weight indicated the total solid content present in the juice sample (AOAC, 1998).

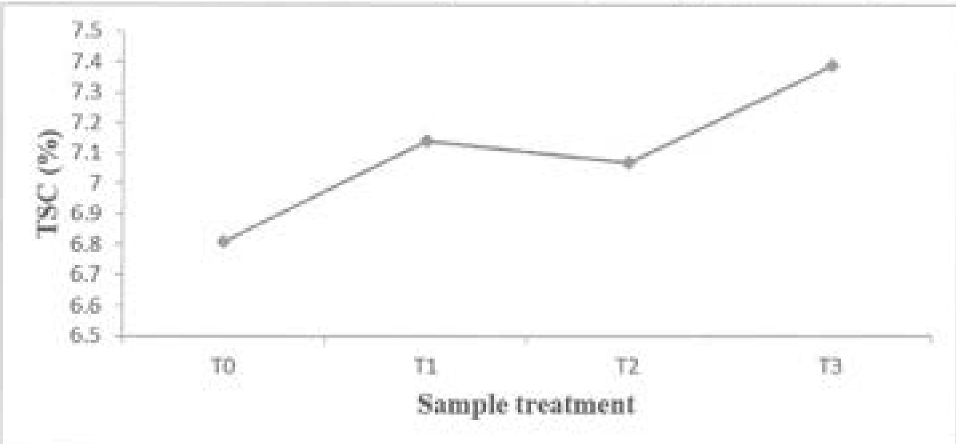

Fig. 3 : Different Fruit Juice Sample treatment Total Solid Content

The Total solid content indicates the solid portion of the fruit present in the juice. In the measurement of blended juices TSC for two replications of each juice treatment. The TSC value ranges between 6.79-7.41 %., shown in appendix IV. For treatment T0, Average TSC value was recorded 6.81 %. Similarly For treatment T1, T2, T3 average TSC value was recorded 7.15 %, 7.07 % and 7.39 % respectively. Sample T3 was better in compare to other three samples because its TSC value was higher. In the consideration of total solid content, Sample T2 was followed by T3.TSC value of Samp e T0 was less compared to others and the sample T1 was greater than T2, but less than sample T3.

Sensory analysis

Panel of 10 judges was selected from the teaching staff and postgraduate students of the CAET, Dediapada, those who were supposed to be surely familiar with beverages assessment. Sensory evaluation (appearance, color, flavor, aroma, texture and overall acceptability) of preserved blend juice was carried out using a 9 point hedonic scale. (Amerine, 1999).

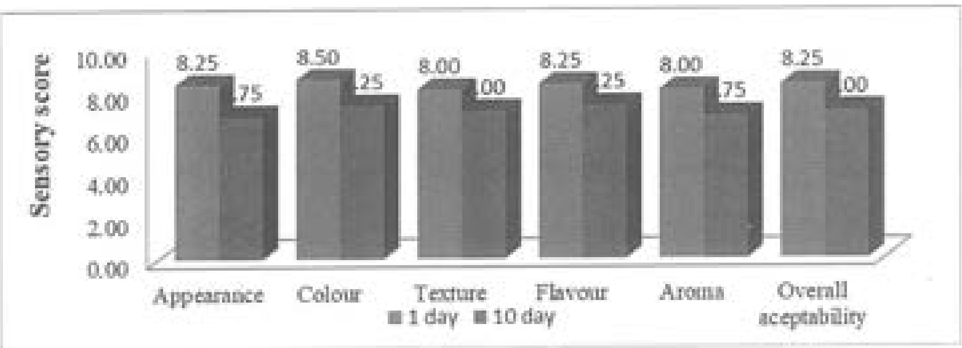

Fig. 4 : Sensory evaluation

The produced juice blends were subjected to physical and sensory evaluation at 10 days interval of storage time. The effect of storage time on the quality parameters and sensory scores of the prepared blend juices were indicated the acceptance up to specific time period i.e., 7 to 8 days after study storage reading was taken up to 10 days period. There was a considerable decrease in pH during storage. In case of the sample T0 pH value was lower according to other samples and T3 sample has higher value of pH 4.44, clarified that the blend juice followed by the treatment T_3 was less acidic in nature. At first day TSS of the samples were ranged from 11.5 to 17.3, which were gradually increased to 12.6 to 18.3 during 10 days of storage. The appearance, colour, flavor, texture and aroma were also changed, this data considered in fig.4. These all data suggested that the gradually variation occurred in the juice sample as per time passed.

Conclusions

Pineapple, carrot and orange were selected and process developed for the juice preparation. As per the standardization all steps were followed for blend juice making. Determination of juice quality by sensory analysis with the help of 9-point hedonic scale. Physical properties like pH, Total soluble solid and total solid content measured by different instruments and methods. The properties were determined daily up to 10 days continuously. Juice samples were stored at low temperature (below 5°C) because of avoids the damage by the microbial activity. Pineapple juice blend with carrot and orange juice were successfully produced and analyzed for sensory and physical properties. Based on study, concluded that sensory evaluation of the juice sample T3at the first day with score of 8.25 (Like very much) and at the end of storage with 7.0 (Like Moderately) average score recorded by hedonic scale. Juice sample T3has variations in pH (4.11 to 4.41), Total Soluble Solid (11.58 to 12.5 °Brix) and Total Solid Content (7.40 %) measured during the storage time. Hence, pineapple juice blend with carrot and orange juice in proportion of (60:35:05) was most effective juice and formulation of mixed blend juice beverage is possible to satisfy consumer taste and preferences. The product was safe during 7-8 days of storage with superior acceptability.

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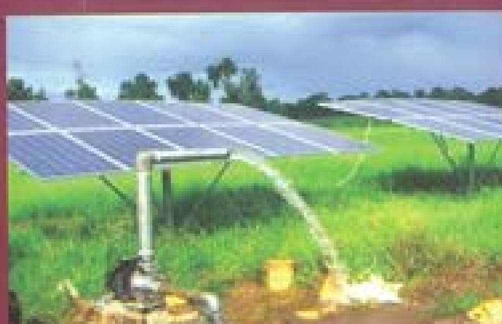

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ISBN : 978-81-7906-934-9
9788179069349