ICAR-National Agricultural Higher Education Project

Project Report (up to March 31, 2023)

Component 1b: Centres for Advanced Agricultural Science and Technology (CAAST)

University of Agricultural Sciences, Bangalore (UASB)

Center for Next Generation Technologies in Adaptive Agriculture

University of Agricultural Sciences,
Bangalore (UASB)

Executive summary

Name of the AU: University of Agricultural Sciences Bangalore

Project Title: Center for Next Generation Technologies in Adaptive Agriculture

Executive Summary:

The program on Next Generation Technologies (NGT) in Adaptive Agriculture (AA) in four thematic areas was initiated at the University of Agricultural Sciences, Bangalore (UASB) under the Centre for Advance Agriculture Science and Technology (CAAST) scheme of the National Agricultural Higher Education Project (NAHEP) of the Indian Council of Agricultural Research (ICAR) during the year 2018-19. There are four objectives in this program, which include a research component, skill development, training and demonstrations, and strengthening infrastructure for post-graduate programs of the UAS Bangalore. Under CAAST, modern infrastructure facilities have been created, and many training programs (lecture workshops and hands-on activities, totalling 68) have been conducted to benefit faculty and post-graduate students. The program supported international training for 14 faculty and five PG students. Eighteen PhD and seven Master's students worked on the CAAST project.

Research on four different chosen thematic areas was conducted with the help of post-graduate students. Research on reduced runoff farming technologies for inclusive development of drylands under climatic distress was attempted. Studies were conducted to quantify the runoff, and soil loss under different crop management practices to study the moisture dynamics, yield and economics. The rainwater collected was used for protective irrigation, which resulted in 20-30% enhanced productivity. One patent for the storage of food grains was granted, and one was filed. Nine valued added products from dryland crops (millets) were developed and demonstrated in the project. In the precession crop breeding program, molecular (SSR) markers in finger millet, dolichos bean and horse gram have been developed and validated. Optimisation of breeding scheme for genomic selection in dolichos bean, has been done, and marker-assisted backcross breeding for enhanced resistance to blast disease in promising quality rice genotype KMP-149, and marker-assisted introgression for Late Wilt Disease (LWD) resistance in maize have been attempted. With the aim of modulating plant physiological processes to impart stress resilience using endophytes, over 300 endophytes (both fungi and bacteria) have been isolated from plants adapted to extreme habitats, and an endophyte library specially adapted for abiotic stress tolerance established. Improving climate resilience in crops using endophyte enrichment technologies was explored, and the study demonstrated the direct role of endophytic fungi in boosting plant growth and imparting tolerance to both field and horticultural crops against abiotic (drought and salinity) stresses. Pest and disease forecasting models were developed and validated for effective crop protection. Twenty-one research articles are published in peer-reviewed journals with a total impact factor of 93.93 and a total NAAS rating of 192.24.

The Reduced Runoff Farming (RRF) demonstration units and Central Instrumentation Facilities (CIF) established under this program are used for teaching and research activities. Revolving fund models have been developed for the sustenance of the CIF and RRF in the post-project periods. The grants allotted were fully utilised and invested in higher education activities of the University.

Introduction

In the post-green revolution, India might be at a crossroads of food and nutritional security. This is attributed to the burgeoning population coupled with ever-decreasing arable land resources and climate change-driven production constraints. This underscores the urgent need for increasing agricultural production. In this context, the use of precision breeding tools for trait improvement, models to forecast pests and diseases for their effective management, micro-biome enrichment technologies for mitigating biotic and abiotic stresses, biosensors for effective cultivation of crops and judicious natural resources management, etc., are needed to sustain yield levels in major crops. The judicious application of such modern tools and techniques could help in overcoming the current yield ceiling in many crops and in combating the challenges of increasing yield under stressful environments. This program addresses some of these major issues in a comprehensive interdisciplinary manner.

Based on the existing strengths and research leads, a program on Next Generation Technologies (NGT) in Adaptive Agriculture (AA) in specific areas was implemented at the University of Agricultural Sciences, Bangalore, under the Centres for Advance Agriculture Science and Technology (CAAST) of the National Agricultural Higher Education Project (NAHEP) of ICAR. The NGT in AA program of UASB addressed four objectives. Objective 1, which includes the research component, is divided into four activities. Objectives 2, 3, and 4 involve skill development, training, and demonstrations, including strengthening the ongoing post-graduate programs of the UASB.

The aim
Human Resource Development (HRD) in four different chosen areas of agricultural technologies
Strengthening infrastructure for postgraduate teaching and research
Research on the chosen areas of agricultural technologies

The specific objective
1: Research
Research on reduced runoff farming technologies for inclusive development of drylands under climatic distress (Activity 1a)
Research on precision crop breeding, including the use of advanced genomic tools & introgressiomics (Activity 1b)
Research on micro-biome (endophyte) enabled seed priming to modulate plant physiological processes (Activity 1c)
Research on forecasting pest and disease outbreaks for effective management (Activity 1d)
2: Training and skill development in the above four chosen areas (Actvity1a to 1d)
3: Demonstration and deployment of the select technologies and establishment of industry linkages
4: Strengthening infrastructure facilities for development and training in the chosen areas

1. Key activities carried out under the project during the entire period

Reduced runoff farming practices for soil moisture distress in the Eastern dry zone of Karnataka

Experiments have been conducted with an objective to harvest runoff water from the micro-watershed and greenhouses for multiple purposes. The major crops such as French bean, Finger millet; Pigeon pea + Field bean (1:1); Finger millet + Pigeon pea (8:2); Kitchen garden (Beans, Chilli, Green leaf, Brinjal, Ridge gourd, Radish, Tomato, Curry leaf and Drumstick) and perennial mixed fruit crops (Pumelo + Guava) are being cultivated in different catchment areas. The water collected in farm ponds are used as protective irrigation during moisture stress conditions, which enhanced productivity by 20-30% in different crops. An experiment was conducted to quantify the runoff, and soil loss under different crop management practices to study the moisture dynamics, yield and economics.

Runoff collected in trenches in finger millet and groundnut plot

To increase infiltration and percolation subsoiling was carried under two cropping systems (finger millet + pigeon pea (8:2) and groundnut + pigeon pea (8:2)) with five sub soiling treatments

Finger millet + Pigeon Pea (8:2) *Groundnut + Pigeon Pea (8:2)*

Development of ecofriendly storage technology and value-added products from dryland crops

Millets are one of the oldest foods known to humans; they are hardy and grow well in dry zones under marginal soil fertility and moisture conditions. Kodo millet (*Paspalum scrobiculatum*) is perhaps one more addition to the proliferating list of healthy foods. Not much work has been done in the utilization of this millet, hence the present study was taken up with an objective to *develop value added products* from kodo millet, analyse their nutritional quality and shelf life. Some of the products prepared from kodo millet are *Kodo khakhra, Kodo Masala Khakhra, Kodo Idli Mix, Kodo Dosa Mix, Kodo Pulav Mix, Upma Mix, Roti Mix, Kodo* and *khoa based barfi* and *Gulab jamun*.

Dairy is an important component in dryland framing system. To minimize the spoilage of milk, an efficient solid-state cooling module for raw milk cooling was developed, which is noiseless green technology (without CFC release). For long-term storage of food grains under dryland conditions, a sub-baric grain storage system was developed, and the invention was patented.

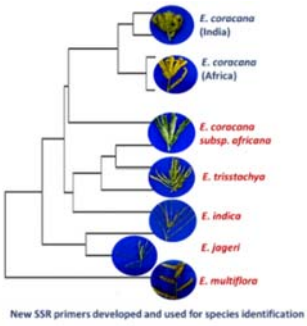
Value added products from Kodomillet

Precision crop breeding

Marker-assisted breeding is important for targeted crop improvement. Different types of markers have been developed in dryland crops and validated under the CAAST project with the help of post-graduate students. The important output of the post-graduate research activity is presented below.

Development and validation of newly designed SSR markers in finger millet

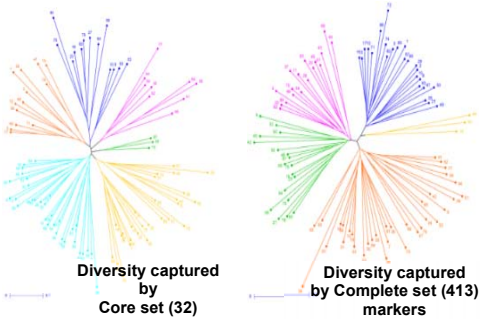
- Developed and validated 550 SSRs (genomic and EST) using the whole genome sequence of *Eleucine coracana* and *E. indica* species and also from the EST sequence from NCBI database.
- Genomic potential of developed markers was assessed using 38 cultivated species and 8 wild species of *Eleusine*.
- Genomic resources were developed in orphan millets like kodo millet, little millet, barnyard millet and proso millet through transferability studies.
- Association mapping panel (350 genotypes) has been phenotyped for drought tolerance and seed yield over two seasons and QTL mapping is in progress.



New SSR primers developed and used for species identification

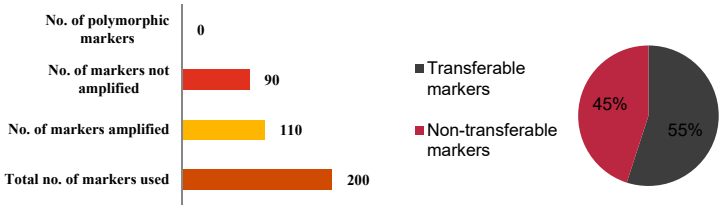
Development and validation of newly designed SSR markers in dolichos bean

- A total of 619 SSR markers have been validated on 96 genotypes & 413 polymorphic SSR markers identified.
- A core set of 32 SSR markers that capture maximum genetic diversity as could be captured using complete set (413) of markers was identified.
- This core set could be preferentially used at all stages of dolichos bean breeding research and development.



Development and validation of SSR markers in horse gram

- Over 55% of the dolichos bean markers were found to be transferable to horsegram.
- Genotyping using other dolichos bean and horsegram-specific SSR markers is in progress.

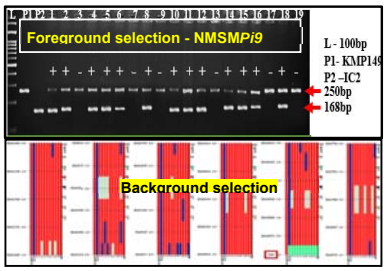


Optimization of breeding scheme for genomic selection in dolichos bean

- Phenotyping of 96 germplasm accessions across five years - 2012, 2014, 2015, 2018 and 2019 completed.
- Data analysis for optimizing the parameters (size of training and cross-validation sets, statistical model and number of markers) to maximize the efficiency of genomic selection is completed.

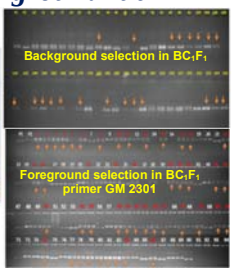
Marker-assisted backcross breeding for enhanced resistance to blast disease in promising quality rice genotype KMP-149

- Two cycles of backcrosses to introgress blast disease resistance genes (*pi9* and *pi54*) to promising quality rice genotype KMP-149 with foreground and background selection completed.
- BC_2F_2 derived from selfing of selected BC_2F_1 are being evaluated for neck and leaf blast with the susceptible check (HR-12). Parallelly, selected BC_2F_1 are being backcrossed to develop BC_3F_1.



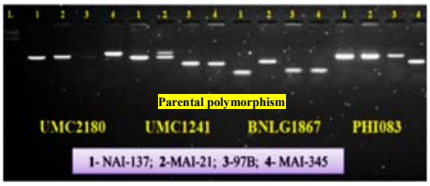
Marker-assisted backcross breeding for late leaf spot (LLS) disease resistance in groundnut

- One cycle of backcross to introgress LLS resistance conferring QTL to popular variety TMV-2 with foreground and background selection completed.
- BC_1F_3 derived from selfing of selected BC_1F_2 are being evaluated for LLS resistance.



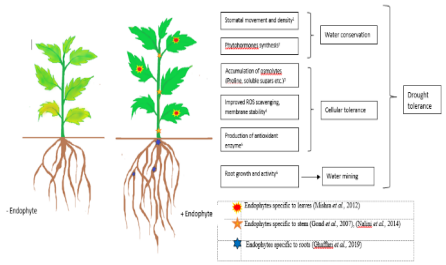
Marker-assisted introgression for Late Wilt Disease (LWD) resistance in maize

- Two cycles of backcrosses to introgress LWD resistance conferring QTL to NAI-137, seed-parent of hybrid Hema with foreground and background selection completed.
- BC_2F_2 derived from the selfing of selected BC_2F_1 are being evaluated for LWD resistance. Parallelly, selected BC_2F_1 are backcrossed to develop BC_3F_1.



Endophyte-enabled bio-priming

Under a fast-changing climate, biotic and abiotic stresses pose a serious threat to crop growth and productivity. New-generation crop breeding and stress mitigation approaches are inevitable to sustain crop growth and productivity. Beneficial microorganisms play an essential role in plant growth and development. They being used as biofertilizers, biostimulants, and biocontrol agents for many years. Microorganisms closely associated with trop plants, namely endophytes, are being prospected for modulating plant physiological processes. Endophytes living in apoplast are considered part of the plant system (holobiome) and interact closely with the host. They regulate several plant traits and can adapt to harsh environmental conditions faster than their host plants. We explored the options for stress mitigation using endophyte enrichment technologies. The study demonstrated the direct role of endophytic fungi in boosting plant growth and imparting tolerance to plants against abiotic stresses.

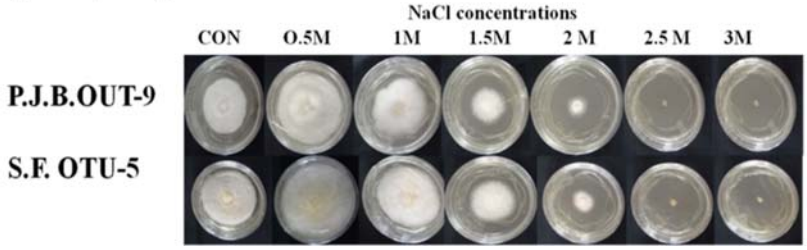


Dhanyalkashmi *et al.*, 2019

Role of endophyte in modulating specific drought traits under water deficit condition

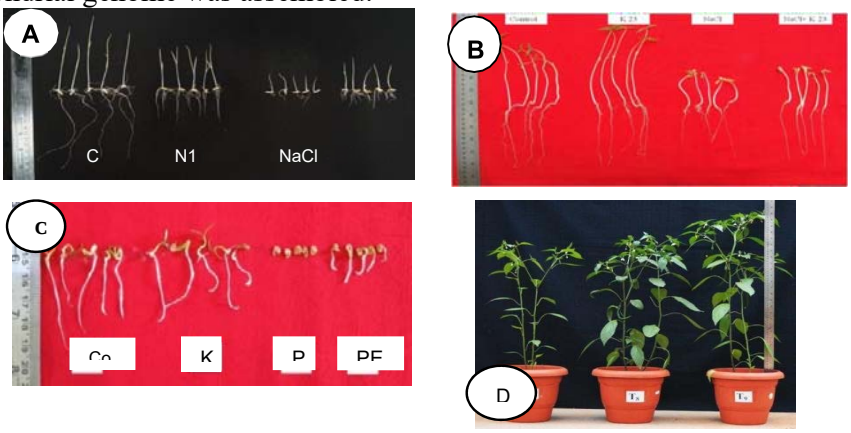
Unique endophytes discovered

Over 300 endophytes isolated from plants adapted to extreme habitats have been characterised, and an endophyte library specially adapted for abiotic stress tolerance has been established.



Growth response of endophytic fungi in control and different NaCl concentrations amended to media (Manasa et al., 2020).

Endophytic fungi capable of imparting salinity and drought stress tolerance to field and horticultural crops were identified. Transcriptome and metabolome analysis were carried out to understand the host-endophyte interactions. The whole genome of one of the fungal endophytes was completely sequenced and mitochondrial genome was assembled.



Effect of endophytic fungal isolate N-10 (A), K 23 (B) and K 23 (C) inoculation on growth of seedlings in different crop system and in system level K 23 (D)

Improvement of resilience to abiotic stress using endophytic fungi in tomato

As an eco-friendly way to enhance crop adaptation to stress, there is growing interest in identifying candidate endophytes. An attempt was made to increase abiotic stress tolerance abiotic stress sensitive tomato variety Arka Saurabh. Select endophytes (*Fusarium sp., F. incarnatum, F. equiseti*) increased seedling growth significantly under drought and salinity stress conditions respectively and imparted stress tolerance. The relevance F. *incarnatum (*K-23) and *Fusarium sp.*, (P-10)) was evaluated for drought stress in pot-grown tomato plants. There

was an increase in morpho-physiological parameters at early seedling growth stages and improved root architecture, yield attributing traits and quality parameters at later stages. These fungal endophytes produced IAA and GA3 under stress conditions. Global metabolome analysis revealed the Differentially Accumulated Metabolites (DAMs) in endophyte-enriched tomato seedlings under stress and control conditions. This study demonstrated that endophytes adapted to extreme habitats could be effectively used to modulate non-host plant responses to abiotic stresses.

Effect of select fungal endophytes on growth and development of drought-sensitive tomato variety, Arka Saurabh (DAT-days after transplanting)

Forecasting pest and disease outbreaks for effective management

Developing weather-based models and forecasting systems can indeed play a crucial role in mitigating the impact of climate change on agriculture and ensuring food security. By analyzing the correlation between weather patterns and pests/diseases, we can predict and prevent outbreaks, thereby reducing the losses in crop production.

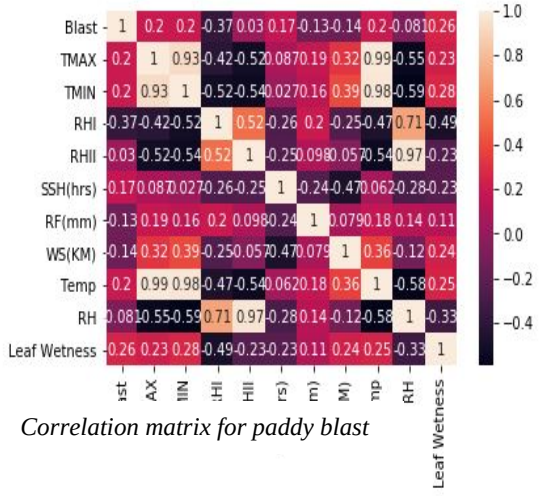
In the case of rice blast, grapes downy mildew, and red gram pod borer, it is essential to understand the environmental factors that contribute to their outbreak and spread. By collecting and analyzing weather data, we can develop models that accurately predict the occurrence of these pests/diseases and provide early warnings to farmers. This information can help them to take timely measures, such as applying appropriate pesticides or implementing cultural practices, to prevent or minimize damage. Additionally, the development of new-generation technologies that improve crop production under uncontrollable conditions is a promising area of research. By combining weather-based forecasting systems with precision farming techniques, we can optimize crop management practices and reduce the reliance on pesticides, thereby promoting sustainable agriculture. Overall, the integration of weather-based models and forecasting systems into agricultural practices can improve the efficiency and sustainability of crop production, and ultimately contribute to global food security.

Rice Blast forecasting model

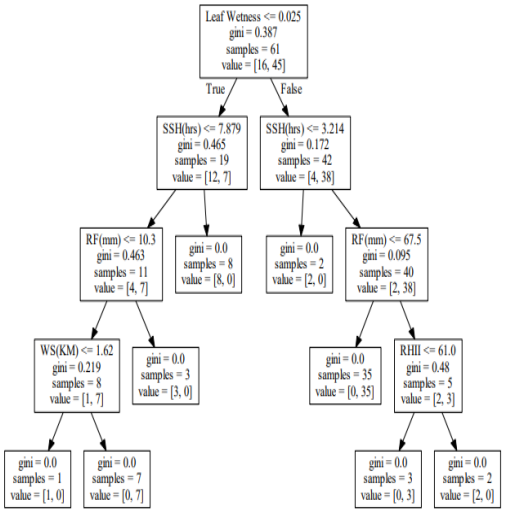
Linear regression Forecast model (Y = -33.58 + (4.57 X maximum temperature) + (-5.49 X minimum temperature) was developed taking into consideration the weather parameters and paddy blast incidence data from 2011-2017; the model was quite promising with an R2 value of 0.84, which was also validated for 2020-21 data. We further advanced our research techniques to Machine learning and deep learning techniques, where we developed a Logistic regression model (accuracy=0.85) and Decision tree models (accuracy=0.96) from the 2017-2019 data, further 2022 data was used to validate the model. Significant negative correlation with minimum and maximum temperature and positive correlation with morning relative humidity during *Kharif* was noticed. Significant positive correlation with minimum temperature and evening relative humidity during summer was recorded. Prediction accuracy of multiple linear regression equation formulated for all the 13 genotypes was ≥ 80 per cent (*Kharif* -2019) and 50-75 per cent during 2020.

Paddy experimental plot at V C Farm Mandya

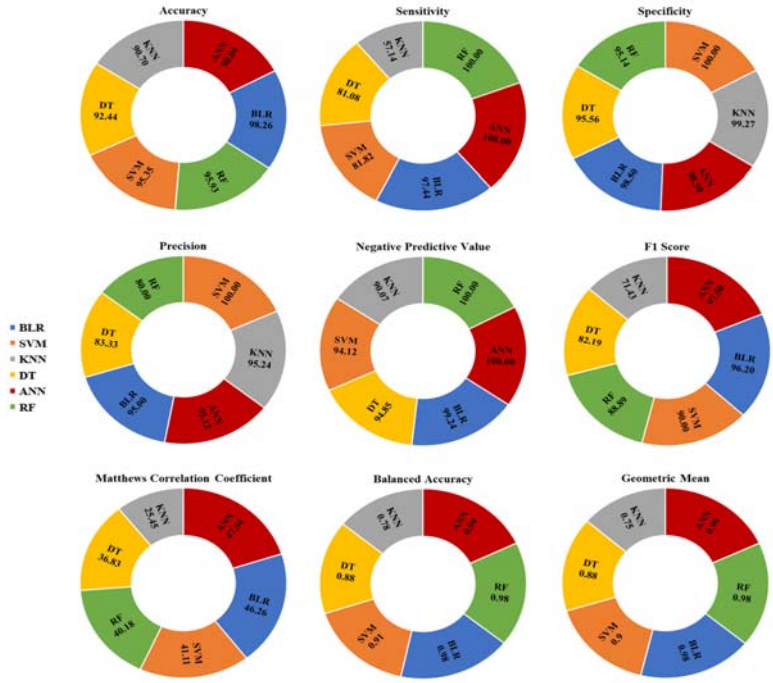
The conventional multiple regression analysis showed 79.00 per cent efficiency in predicting rice blast disease. Our findings unveiled the applicability of ML especially ANN, BLR, SVM and DT methods for rice blast disease prediction in a real environment and showed ≥ 90 per cent prediction accuracy. Among the six ML techniques employed ANN was found to be more efficient in prediction of rice blast followed by BLR. Temperature and relative humidity were found to be significant contributors in prediction of rice blast through ML techniques.



Correlation matrix for paddy blast



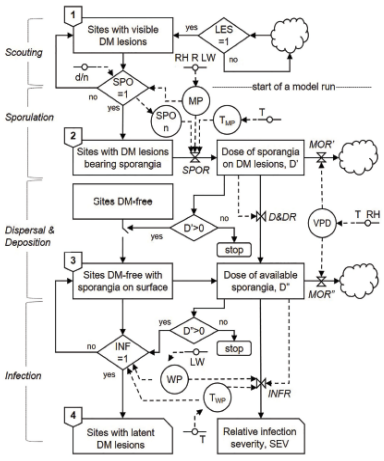
Decision Tree for paddy blast



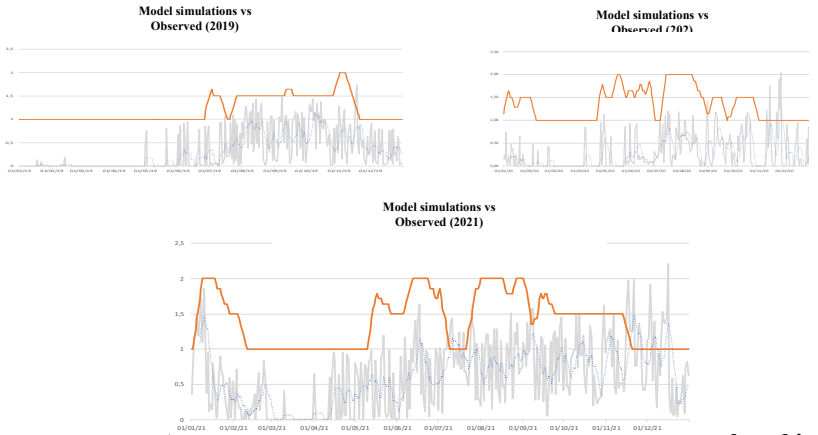
Performance comparison of various ML techniques achieved using all weather variables for prediction of rice blast disease

Grape Downey Mildew forecasting model

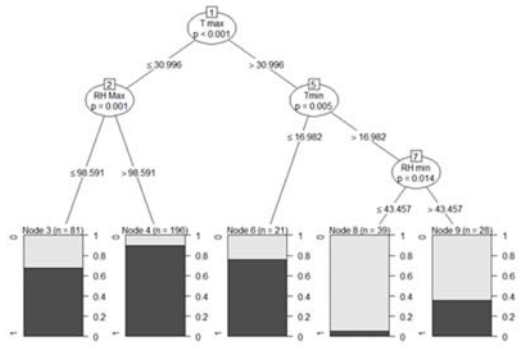
For grape downy mildew, we developed Mechanistic models in collaboration with Catholica University Italy which performed the well under Indian conditions and deep learning techniques like Decision tree was also developed. The results of the model were found to be satisfactory.



Relational diagram of the model predicting secondary infection cycles of *P. viticola*



Mechanical model predictions vs observed data developed in collabarations with Catholic University Italy



Decision Tree for Downey mildew

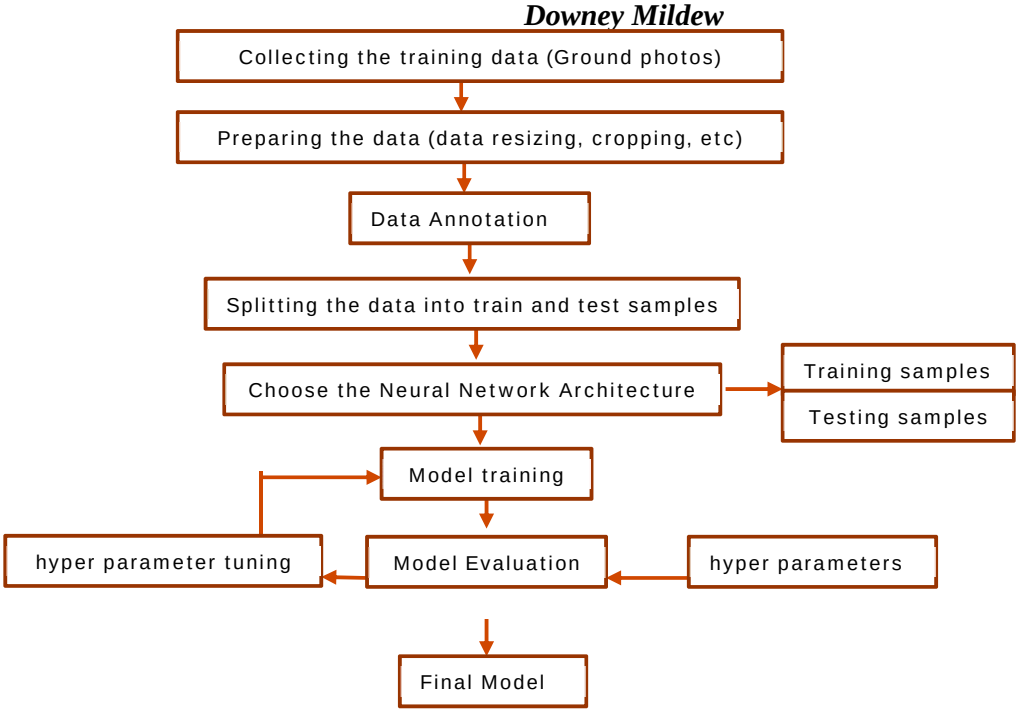
While developing the decision tree model 70 % of the data used for training and (320 observations) 30 % data used for testing (137 observations)

Model has Accuracy of 86.95 per cent with Precision: 85.33 per cent

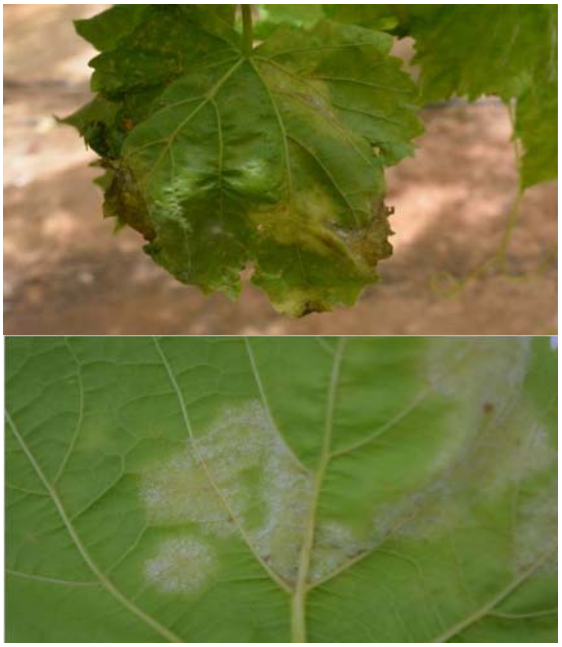
Pigeon pea Pod Borer forecasting model

A multiple regression analysis equations for pod borer larval population dynamics was developed. The lead time concept was used to identify major weather factors contributing to pigeon pea pod borer complex severity. The results showed that the sixth-day weather data *viz,* Max and Min temperature, morning and evening relative humidity, wind speed, cloud cover and potential evapotranspiration (PET) were highly correlated. With this background, stepwise regression analysis equation for pod borer larval population dynamics (Y) = 2.569+(-0.351xTmin) +(0.908xTmax) +(-0.212xRH-I) +(-0.109xRH-II) +(1.465xWS) with R2 value of 0.496 was built, further advanced analytical models will be taken up to improvise the prediction model.

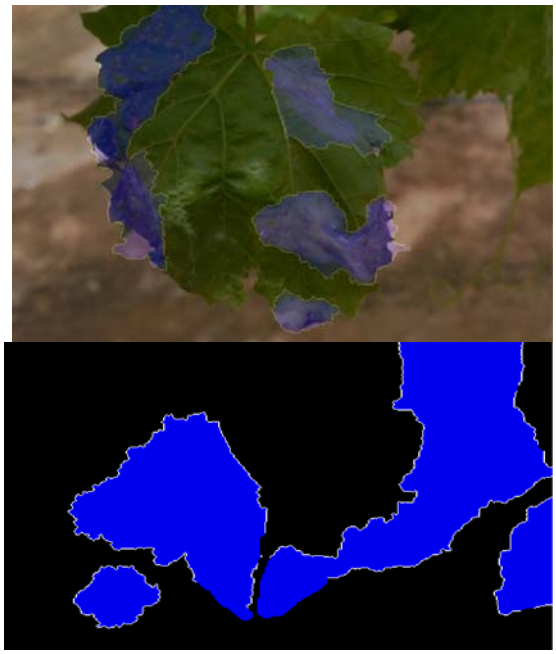
Development of Deep Learning based Model for identification of Stage of occurrence of Disease in Downey Mildew



Methodology of Deep Learning model development



Training Images



Masks showing infected parts of the leaf

1.1. How the facilitative units helped to enhance learning outcomes.

Strengthening infrastructure facilities

With generous support from the Indian Council of Agricultural Research (ICAR), the University established one dedicated *Common Laboratory Facility* (CLF) with basic equipment and working facility to carry out common research activities in the South Block of the GKVK Campus. The University under the aegis of the Centre for Advanced Agricultural Sciences and Technology (CAAST) program of the National Agricultural Higher Education Project (NAHEP), established a **Central Instrumentation Facility (CIF)** in the North Block of the GKVK campus. With the high-end scientific instrument, the CIF will further contribute to pursuing research in many areas of modern science and technology and the development of quality human resource, and thus help the University to keep pace internationally.

Spectral Confocal Microscope (SCM)

Scanning Electron Microscope (SEM)

Gas/Liquid Chromatography-Mass Spectrometry (GC/LC-

Out-of-box initiatives undertaken by the AU

Climate Smart Automated Water-use efficient polyhouse

- 1500 sq. meters polyhouse with rainwater harvesting mechanism was established which facilitate the storage of water just below the polyhouse with 7.5 lakh litre sub surface storage. Which is further used for irrigation

.

OBJECTIVE: To plan and take up continuous crop cultivation (High value crops) using the next gen technologies *viz.*, Soil moisture sensors, IOT based pumping, etc

Crop stand in the polyhouse **Fertigation system**

Solid State Cooling model

Minimize the spoilage of milk in rural areas of India it is necessary to cool milk. The module can maintain temperature of milk at 9°C (below 10 °C is recommended for milk to reduce microbial activity)

Commercialization/Entrepreneurship potential:

1. M/s. Lamark Biotech Pvt. Ltd.
2. Ashna International Pvt. Ltd.
3. Mr. Balbir Singh
4. Auro Indian Pvt. Ltd.

1.2. Collaborations with industry and other HEIs to bring relevancy

1.3. Please provide the details on relevant collaboration with industry for bringing relevancy and improving research effectiveness in the AU in one-two paragraph.

Collaborations	*Activity/achievement/purpose*	*Remarks/Photographs*
Namdhari Seed Company	Collaborative research work	One Ph.D. student awarded the fellowship with research collaboration
Bayer Crop Sciences	Collaborative research work	Two Ph.D. students awarded the fellowship with research collaboration

CULTIVATE, Farm2Fork Technologies Bangalore 76	Automated Farming Solutions-Research	For Farming Automation Solutions-Smart Irrigation, Smart Fertigation and Smart Polyhouse
Friedrich-Schiller University, Jena, Germany	Collaborative research work	Student and faculty training on endophyte research
Wipro India Private Limited	Various areas of research and testing	Pharmaceutical, fast moving consumer goods, Nutraceuticals, Cosmetics, Genomics
Perdue University, USA	Student and faculty exchange	Dual/sandwich Ph.D. programmes
Western Sydney University, Australia	Student exchange and research collaboration	MREs and dual Ph.D. pragrammes
ISRO		Setting up Lighting Detection Sensor(LDS) network
ICRISAT, Hyderabad	Human Resource Development	Two workshops were jointly organized in use of advanced tool for forecasting of pest and diseases

2. Achievements made through CAAST under NAHEP

2.1 Output-outcome monitoring

S. N.	Particulars	Apr'2018 to Mar'2023	
		Target	Achievement
1.	Number of technologies commercialised (under CAAST, one patent granted; 1 filed))	-	0.00
2.	% increase in faculty research effectiveness	-	30.0%
3.	Number of direct beneficiaries of the project	-	73
4.	Number of female beneficiaries	-	25
5.	Number of ARS (trained under the CAAST project)	-	06
6.	Number of students who were admitted to foreign universities	-	05
7.	% increase in PG student placements	-	79% (19 students from CAAST activity)
8.	Number of industry-sponsored projects and positions in cutting-edge areas of agri-science	-	03
9.	Number of faculty training programmes (national) undertaken by AU	-	62
10.	Number of faculty training programmes (international) undertaken by AU	-	14
11.	Number of student training programmes (national) undertaken by AU	-	62+2+2
12.	Number of student training programmes (international) undertaken by AU	-	08

Observation

The progress made against the output-outcome monitoring indicator showcases the success of the project. The approval of two value-added products for commercialisation is a major achievement, which is indicative of the potential impact of the project. The motivation of the faulty of UASB with the training obtained in the NAHEP CAAST project has led to an increase in research output, as evidenced by the high-impact peer-reviewed journals and an overall NAAS rating of 193 for CAAST team publications. Additionally, an increase in externally funded projects submitted and sanctioned by various agencies related to sub-components of the CAAST project is a positive outcome.

The project has also had a positive impact on industry-supported projects funded by seed and pesticide companies addressing farmer needs. The success of the PG students in CAT exams and selection for ARS is a testament to the quality of education and training provided under the CAAST project. The contacts established in the project have also enabled students to pursue higher education in foreign universities, contributing to the overall success of the project. The 68 trainings organized for faculty and PG students have helped them to obtain advanced skills, which have been utilized for teaching and research. The visits of fourteen faculty and seven students to different foreign institutes have also contributed to the advancement of knowledge and expertise in the field.

In summary, the key initiatives that have contributed to the overall outcome/potential impact of the project include commercialization of technologies, increase in research output, success in industry-supported projects, and the provision of advanced training to faculty and PG students. The project has also enabled students to pursue higher education and gain exposure to foreign institutes. These achievements are indicative of the success of the project in achieving its objectives and contributing to the overall development of the field.

2.2 Knowledge Management Collaterals

I. Knowledge Collaterals	Apr'2018 to Mar'2023
1. Publications (manuals, research output, brochures, information notes, book of abstract, training manuals etc.)	15
2. Research Articles, including review papers	21 (total NAAS rating 192.24; IF: 93.93)
3. Annual Reports (NAHEP reports and UASB annual reports)	08
4. Books	0
5. Success Stories	03
6. Newsletter	0
7. Magazines	0
8. Blogs	0

II. Mobile and Web Applications	Apr'2018 to Mar'2023
1. Mobile Applications Developed	NGT-Agricultural Pest Prediction and Advisory (APPA) UAS, Bangalore
2. Web Applications Developed	NGT Forewarning Pest and Disease

Name of the mobile app: NGT-Agricultural Pest Prediction and Advisory (APPA) UAS, Bangalore (https://play.google.com/store/apps/details?id=com.techuva.iot.ngt)

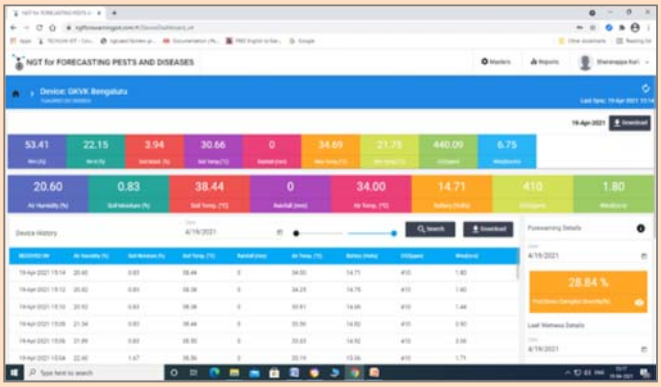
Description: Location-based Agricultural Pest Prediction and Advisory to farming community

Impact: Extension workers and Farmers are using for pest and disease forewarning

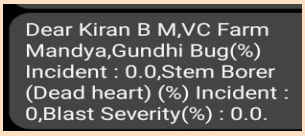
Name of the web application: NGT Forewarning Pest and Disease (https://www.ngtforewarningpd.com/#/Home)

Description: Pest Prediction & disseminating the advisory to the farming community

Impact: Extension workers and Farmers



NGT forewarning Web portal



WhatsApp message

III. Number of IPR (Intellectual Property Rights) Registered/Obtained	Apr'2018 to Mar'2023
1. Copyrights	-
2. Patents	2
3. Others	-

IV. Dissemination and Outreach	Apr' 2018 to Mar' 2023
1. No. of Posts on Social Media	01
2. No. of Posts on Newspaper	01 (Exhibition, in 107th Indian Science Congress)
3. No. of Posts on Magazines	01(Symposium output published in Current Science)
4. No. of Unique Promotional or Outreach Collaterals	01

Capacity building programs to improve the research effectiveness

1. International trainings for students and faculties

Subject areas	*Host institutes, period of training*	*Output of the training*
Students		
Dr. Anilkumar C., Scientist, ICAR-NRRI, Cuttack, Orissa	(BSU) block, CIMMYT, El-Batan, Texcocco, Mexico Duration: 10 Days	Exchange of ideas and views on differentstatistical tools learnt during the international training with the students, researchers and scientists from home Agricultural Universities (AU) and other AUs across the country in a follow-up training programme *i.e.* ten days training programme on Genome-wide QTL detection and prediction of breeding values for precision crop breeding.
Dr. Sunitha N. C., Research Associate, Dept. of Genetics and Plantbreeding, UAS, GKVK, Bengaluru-560065	(BSU) block, CIMMYT, El-Batan, Texcocco, Mexico Duration: 10 Days	
Santosh Nagappa Ningoji, Ph. D Scholar, Dept of Agronomy, UAS, GKVK, Bengaluru.	Galilee International Management Institute, Israel. Duration-10-23 September 2019	The training helped to understand and upgrade knowledge and skill in the field of agricultural water management. New concepts/ technologies such as high-tech horticulture, precision agriculture using micro irrigation, and doubled wall-protected cultivation for water management were learnt. Knowledge gained during training program will help in prioritising research in the field of horticultural water management, and refinement of these technologies/approaches for a large scale adoption by the farming community.
Satya Srii Ph. D Scholar, Dept of Seed Science and technology, UAS, GKVK, Bengaluru.	Visit to Developmental Biology Laboratory, Sorbonne University, Paris	*Interesting results from the project*: The transgenerational memory is shown be imparted by pericarp during germination by influencing seed oxidative state and the manuscript has been submitted for publication in international journal.

	Duration - 29th October 2021 to 29th January 2022.	The candidate got expertise in working on seed coats, oxygen mapping, antioxidant assays and cold plasma generation.
Roopashree, B. Ph. D Scholar, Dept of Seed Science and technology, UAS, GKVK, Bengaluru.	Friedrich Schiller University Jena (FSU), Germany. Duration – 2 months	The candidate studied the relevance of selected endophytes in regulating phytohormone levels under in-vivo conditions, and also attempted to elucidate the mechanisms adopted by the endophytes in modulating plant growth under abiotic stress conditions using metabolome and transcriptomic approaches
Pallavi, N. Ph. D Scholar, Dept of Crop Physiology, UAS, GKVK, Bengaluru.	Friedrich Schiller University Jena (FSU), Germany. Duration – 2 months	
Kiran B. M Ph. D Scholar, Dept of Pathology, UAS, GKVK, Bengaluru.	Catholic University of Sacred Hearts, Piacenza, Italy Duration – 47 days	The student got training on development of mechanistic models for downy mildew of grapes. Tested and evaluated the mechanistic models under India conditions. He developed models which could predict number of possible infection events based on life cycle of downy mildew pathogen under Indian conditions
Rachana Krishnamurthy Pawar	Friedrich Schiller University Jena (FSU), Germany. 19th February 2022 – 26th March 2022	The student studied changes in the cytoplasmic calcium to predict the downstream signalling in Arabidopsis upon colonization of the endophytic fungus. This has helped the candidate to understand the unique downstream signaling mechanism during endophyte colonization.
Faculty		
Dr. S. Rajendra Prasad	**Institution-North Caroline State University, North Carolina, USA Duration-19-30 August 2019**	MoUs have been developed and signed, and three students will be sent to USA for training under CAAST program.
Dr. Nataraja Karaba N	Institution: Friedrich-SchillerUniversity (FSU), Jena, Germany Duration – 10-25 May 2019	New connections for collaborative research were established in three different research institutes (FSU, HKI and MPI, Jena Germany). MoU has been signed between UASB and FSU for collaborative activities in skill development and research. Prof. Ralf from FSU has been nominated as Adjunct Faculty to UASB, and Prof. Nataraja was nominated as an expert for the Indo-German Science and Technology Centre (IGSTC) sponsored joint Indo-German held at Jena, Germany. Prof Nataraja facilitated the hands-on training for three PhD students, and one faculty was trained at FSU, Jena. Five research papers have been jointly published post-visit to FSU.
Dr. C T Ramachandra	Institution: School of Food Science,	Good linkages are developed with various departments, schools and advanced centres at WSU, Pullman. A good

	Washington State University (WSU), Pullman, USA Duration – 15 Feb -20 March 2020	network was established for sending our Master's and Ph.D. students for collaborative research in future.
Dr. M.S. Nagaraj, Associate Professor of Plant Pathology, ARS, Gunjevu- H.N.Pura, Hassan.	**Leibniz institute of plant genetics and crop research (IPK), Gatersleben, Germany** 19thFebruary 2022 to 29thMarch	Exposure to molecular work and Machine Learning (ML). In machine learning exclusively worked on Image Analysis equipment's and working models of *BLUEVISION MICRO*; RBG, MACROBOT and HYPERSPECTRAL MICROSCOPE. All these equipments are used for phenotyping of the initial phases of plant- pathogen interaction. It delivers precise information on pathogen behaviour, the host early response, biomass and growth virtually eliminating environmental effects. These uses analytical methods to identify patterns and make decision with minimal human intervention
Dr. Rajendra Prasad B S **Assistant Professor Scientist (Plant Protection), KVK Ramanagara**	Dept. of Crop and Forest Sciences, University of Lleida, Avda. Alcalde Rovira Roure, 191 25198 – Lleida (Spain) **10th January to 28th March, 2022**	The effect of several chemical stimuli on the oviposition behaviour of 3 moth species (*Cydia omonella*, *Lobesia botrana* and *Grapholita molesta*) is identified and the information can be used for effective management strategies. These results will conduct to the publication of a scientific article.
Dr. Murali Mohan K **Professor,** **Dept of Entomology, CoA, UAS, GKVK, Bengaluru**	**IRTA Research Centre University of Lleida, Spain** Deputation: 10th January to 28th March, 2022	✓ Obtained Hands-on-Training regarding laboratory rearing of thrips ✓ Acquainted with the bioassay techniques employed on adult and larval stages of thrips for detection and quantification of insecticide resistance ✓ Got Hands-on-Training on quantification detoxifying enzymes associated with insecticide resistance ✓ Utilization of laboratory bioassay data to predict the insecticide resistance across space and time
Dr. Nagesha S N, **Assistant Professor of Bioinformatics** **College of Agriculture, Hassan, University of Agricultural Sciences, Bangalore**	**Leibniz Institute of Plant Genetics and Crop Plant Research, IPK, Gatersleben, GERMANY** **19thFebruary 2022 to 29thMarch 2022**	Successfully undergone training in Germany (IPK) on **Grain Legume genomics and Genome Editing**, Further, established the collaboration with IPK, Germany
Dr. Nethra, N **Assistant Professor Seed Science and Technology** **CoA, UAS, GKVK, Bengaluru**	Visit to Developmental Biology Laboratory, Sorbonne University, Paris 29th October 2021 to 29th January 2022.	➢ Interesting results from the project: the transgenerational memory is shown to be imparted by pericarp during germination by influencing seed oxidative state and the manuscript entitled **"Influence of pericarp in oxidative state of transgenerational stressed sunflower (*Helianthus annuus* L.) seeds"** has

		been **submitted for publication in international journal is under process.** ➢ Got expertise with working on seed coats, oxygen mapping, antioxidant assays and cold plasma generation.
Dr. Mahesh H B Assistant Professor Genetic sand Plant Breeding	Training area- **Gene Editing, Genomics, Plant Breeding**	• The candidate got an exposure on CRISPR technology and its potential application in Agriculture
Dr. Geetha Govind, Assistant Professor (Crop Physiology) College of Agriculture, Hassan, UASB	Friedrich Schiller University Jena (FSU), Germany 20th November 2021 to 15th February 2022	She has undergone training to explore host-endophyte interactions. The information generated and knowledge gained can be used to develop low-cost effective measures for abiotic stress tolerance by using endophytes. She co-authored a opinion paper with the collaborator.
Dr. C. N. Lakshminarayana Reddy Associate Professor, Department of Plant Pathology, College of Agriculture, Bengaluru	Department of Biosystems- Division of Crop Biotechnics, Laboratory of Tropical Crop Improvement, Willem De Croylaan 42 Box 2455, 3001 Leuven, Belgium 07.02.2022 to 23.03.2022	The programme gave an opportunity to learn the various techniques in understanding the endophyte-virus interactions such as novel sequencing tools, genome editing tools, cryopreservation, phenotyping.
Dr. S. Ramesh Professor, Dept. of genetics and Plant breeding CoA, UAS, GKVK, Bengaluru	Institution: CIMMYT, Mexico) Duration – 15-26 July 2019	The visit enabled exposure and interaction with the researchers at CIMMYT, a renowned international CGIAR institute. The hands-on-sessions on statistical tools to handle huge phenotypic and genotypic data were informative. Visit to the wheat speed breeding facility and maize research fields exposed us to the technologies operated at CGIAR institutes.
Dr. S. B. Yogananda	NC State University, Raleigh, North Carolina, United States. 24th March 2022 to 31st May 2022	The visit enabled exposure and interaction with the researchers at NC State University. The hands-on-sessions and visits to various facilities and laboratories was useful to conduct the research in the area of reduced runoff farming. The candidate underwent training on developing low cost weighing lysimeter for water use efficiency studies
Dr. C A. Deepak, Junior Rice Breeder, AICRP (Rice), ZARS, V. C. Farm, Mandya	International Rice Research Institute (IRRI), Los Banos, Philippines 31st May 2022 to 26th August 2022	Precision Crop Breeding including the use of Advanced Genomic Tools and Introgressions

2. National trainings for students and faculties

Details presented in *Annexure*

2.2 Input and activity monitoring

	Capital	Revenue
Total funds sanctioned during 2018-2023 by PIU (INR Lakhs)	7,05,93,000.00	**12,94,07,000.00**
Total funds received till March 31, 2023 (Cumulative) (INR Lakhs)	**7,05,93,000.00**	**12,94,07,000.00**
Total expenditure up to March 31, 2023 (INR Lakhs)	**7,17,47,049.00**	

Input / Activity indicator	Sub- head / category	Apr'2018 to Mar'2023 Expenditure / input in INR lakhs		Activity elaboration
		Utilization	Planned	
Goods and equipment	Equipment, Plant & Machinery	28119920.00	28120000.00	
	Office equipment	600000.00	600000.00	
	Laboratory equipment	30318653.00	29153000.00	University contributed additional funds required for establishing a central instrumentation facility.
	Furniture & fixtures	1657465.00	1664000.00	
	Computers and Peripherals	1913243.00	1915000.00	
	Books and Journals	398603.00	400000.00	
Civil works	Minor repair and renovation work	8739165.00	8741000.00	Renovated PG student research laboratory, field facilities, greenhouses and roof water harvesting
Human capacity building	National level training	0.0	0.0	
	International level training	13330902.00	14025000.00	Both faculty and students trained
	Short visits/ seminars	1249000.00	1249000.00	
	Meetings and workshops	872402.00	873000.00	
Consultancy	National level consultancies	954233.00	960000.00	
Recurrent cost / Miscellaneous	Travel	1245122.00	1248000.00	
	Contractual services	26223000.00	26223000.00	
	Operational costs	78535731.00	78668000.00	
	Institutional charges	6161000.00	6161000.00	
Total		200318439.00	200000000.00	

Observation
The funds allocated were utilised as per the category/subheads. For laboratory equipment, the university also contributed; therefore, expenditure is more than the sanctioned budget from the NAHEP.

2.3 NAHEP outreach and other unique initiatives undertaken

a) Case studies/success stories developed under NAHEP
(establishment of own enterprise by beneficiary student/high-impact research carried-out by AU under NAHEP/enhanced students learning outcomes due to establishment of modern facilities under NAHEP etc.)

SUCCESS STORIES:

Climate Smart Automated Water-use Efficient Polyhouse established

1500 sq. metres polyhouse with rain water harvesting mechanism

The harvested water stored just below the Polyhouse- 7.5 lakh litres Sub Surface Storage Tank ONLY harvested rain water used for irrigation.

OBJECTIVE: To plan and take-up continuous crop cultivation (high value crops) using NEXT GEN Technologies *viz.*, soil moisture sensors, IOT based pumping, etc.

Recycling

Crop stand in the Polyhouse

Fertigation System

3D printed honeycomb cells with honey and sealing

b) Knowledge management and outreach initiatives (development of collaterals, newsletter, social media outreach activities, creation of website, experiential learning workshop, exposure visits,)

1. **Developed a website NGTCAAST**

2. Webpage to advertise the facilities created under the CAAST_NAHEP project (https://uasbangalore.edu.in/index.php/central-instrumentation-facility-en)

c) Unique initiatives undertaken

The university developed infrastructure facilities for teaching, and other related activities (administration, examination and evaluation) using different funding resources. The CAAST project helped the UASB to strengthen these facilities. Some of the digital infrastructure developed is indicated below.

1. Digital infrastructure

(*development of digital/smart classroom, virtual reality facility, digital library system, other digital education and administrative infrastructure, Agri Diksha, AMS implementation etc.*)

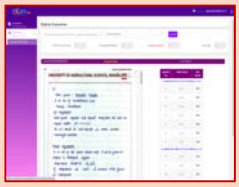
Digitalisation of library and related information systems provides ample utilisation of e-resources for students and faculty. The facilities such as *Digital Podium for Lecturer; Interactive Panel; Visualizer; Tracking Camera; Front Camera; Interactive Flat Panel, and Audio System* have been developed and are effectively being used.

Video Library cum Virtual Class Room

2. Digital initiatives:

(*organizing trainings through online, conducting online examinations, administering attendance, developing of web applications, e-learning modules etc.*).

Sl. No.	Category of the collateral	Digital initiative	Practice before introduction of the initiative	Practice after introduction of the initiative
1	**Education**	**Decentralized/ Centralized Digital Evaluation**	Offline	Online evaluation
2	Administration	**NAD_Digilocker system**		Students are advised to register on Digilocker to access their awards. Uploaded **2590 Degree Certificates** into the NAD_Digilocker system
3	Administration	**Digital Registration Process**	Offline	Digital registration process has been initiated at the university to help the students make the easy and contactless payment



NAD Digilocker system

Digital Registration Process

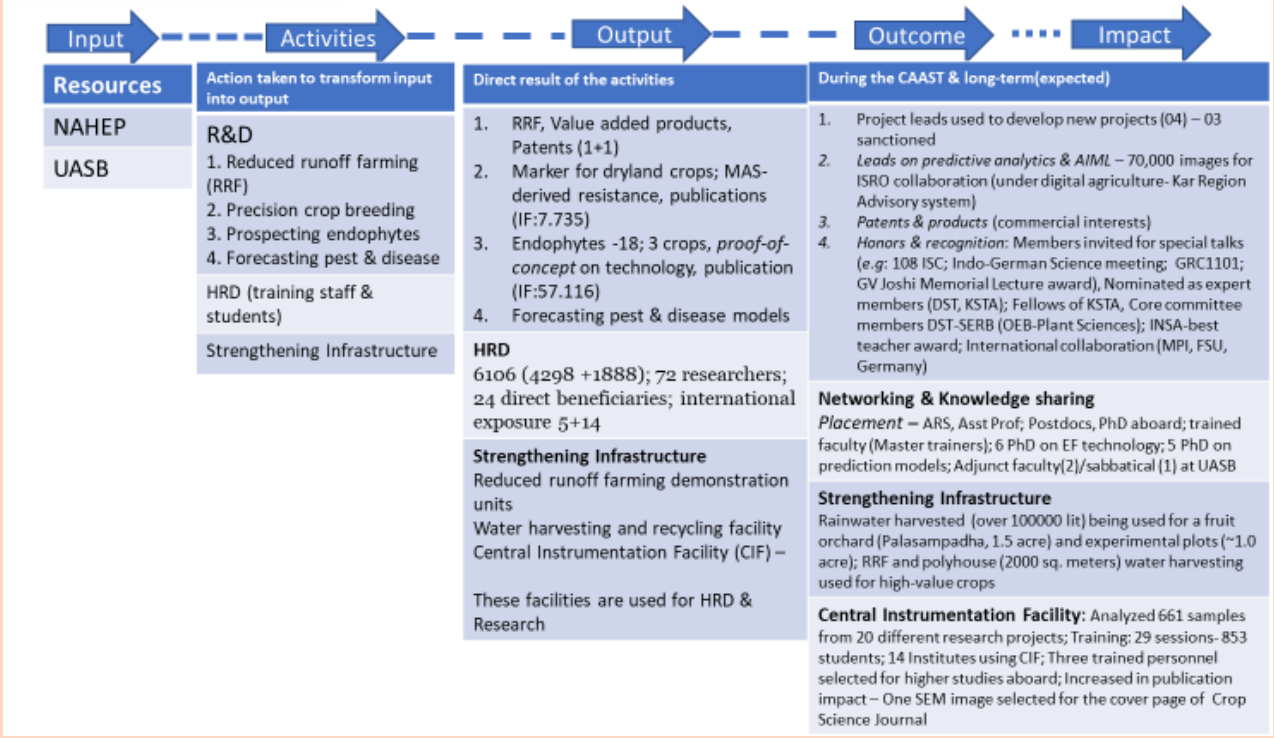
Decentralised / Centralized Digital Evaluation

3 Potential impact of the intervention:

Observation

<<Please provide the explanation on potential impact of the intervention in short and long term while illustrating the key initiative/activity

CAAST at UASB...result chain



4 Challenges faced and lessons learned while implementing the project at AU:

Challenges	
1	The proposal was initially developed for PG research in the chosen area, and subsequently, international training was inserted as HRD component. There was uncertainty about the budget head to be used for international training for HRD. Identifying the matching laboratory for student training and fixing the duration without affecting the committed academic activities was one of the challenges.
2	Covid-19 restrictions for international training of faculty and student were the major issue during the project period.
Lessons learned	
1	The project helped the University to coordinate multidisciplinary activities, including research and human resource development.
2	COVID-19 lockdown facilitated innovative thinking (online classes, online written examinations, answer book evaluation; webinars with international partners, online viva voce examinations) and managed the crisis without compromising the quality of education and research. Facilities generated under CAAST were effectively used to manage the crisis, and hence university is proposing to strengthen such facilities.

5 Sustainability Plan

5.1 Sustainability plan of the AU

- *Does the AU have any sustainability plan for to make AU future-ready and globally recognized? (**Yes** / No)*
- *If yes, details thereof?*

Human resource development: Trained manpower for fast-changing agri-science and technology is needed. UASB is strategically planning and executing the plan by revising the course curricula at regular intervals. Dual degree programs and sandwich degrees have been introduced with international universities, and regular student exchanges program are being implemented. Under CAAST, international linkages have been established, trained 14 faculty, who are now exposed to modern tools and technologies. The training faculty members are now attempting to write grants with well-focused scientific questions. The international network established will be sustained as there are matching done as per the mutual interest and benefit. Under CAAST, a couple of faculties have been nominated as Adjunct Faculty and their involvement has made a significant impact.

5.2 Sustainability plan for improving internal revenue generation through facilities and infrastructure created under the project

Infrastructure: The facilities established under the CAAST will be maintained with in-house support and UASB has already made specific plans. The revolving fund model has been implemented to sustain Central Instrumentation Facility and the pay-and-use model in a cost-effective way is giving good returns. The revenue generated will be used for AMC and maintaining the facility for training and research activities.

6 Contribution of each individual in project

6.1 Name of Vice Chancellors(s) during project duration and contributions of each PI, Co-PI and team along with their photographs

Name	Gender	Designation in AU and contact details (email, mobile)	Role in project (PI/Co-PI/RA/SRF etc.)	Major contribution/output
Dr. S. Rajendra Prasad	Male	Vice Chancellor, University of Agricultural Sciences Bangalore (UASB)	Principal Investigator CAAST project **(31.03.2018 to 16.09.2022)**	Executed the project and facilitated the development of infrastructure facilities
Dr. N. Nataraja Karaba	Male	**Professor,** Dept. of Crop Physiology, University of Agricultural Sciences Bangalore-560065	Principal Investigator **(17.09.2022 to till date)** and Coordinator (Activity 1c)	Served as Coordinator of one of the major activities (1c), coordinated overall work, data generation and compilation, and report preparation.
Dr. S. Ramesh	Male	Professor, Dept. of Genetics and Plant Breeding, UASB	Co- Principal Investigator and Coordinator (Activity 1b)	Served as Coordinator of one of the major activities (1b), contributed for data generation and compilation
Dr. Ramachandra C. T.	Male	Professor, Department of Agricultural Engineering, UASB	Co-Principal Investigator and Coordinator (Activity 1a	Served as Coordinator of one of the major activities (1a), contributed for data generation and compilation
Dr. M. K. Prasanna Kumar	Male	Professor, Dept. of Plant Pathology, UASB	Co- Principal Investigator and Coordinator (Activity 1d)	Served as Coordinator of one of the major activities (1d) and contributed for data generation and compilation.
Dr. Venkatesh	Male	Comptroller, University of Agricultural Sciences, Bangalore	Finance Officer	Managing finances of the program
Dr. Siddayya	Male	PME UASB	PME	Project monitoring and evaluation
Dr. Gopinath G	Male	University GRM Officer UASB	University GRM Officer	
Dr. L. Vijaykumar	Male	College of Agriculture, VC Farm, Mandya, UASB	GRM Officer	
Mr. B. Krishnamurthy	Male	Procurement Officer UASB	Procurement Officer	
Dr. K T Prasanna	Male	Environmental safeguard Specialist, UASB	Environmental Safeguard Specialist	

Dr. D. L. Savithramma	Female	Professor, Dept. of Genetics and Plant Breeding, UASB	Co- Principal Investigator	
Dr. R. Uma Shanker	Male	Professor, Department of Crop Physiology, UASB	Co-Principal Investigator,	
Dr. N Earanna	Male	Professor, Department of Agricultural Microbiology, UASB	Co-Principal Investigator,	
Dr. E. Gangappa	Male	Professor, Dept. of Genetics and Plant Breeding, UASB	Co-Principal Investigator	
Dr. P.L. Devaraju	Male	Professor, Department of Seed Science & Technology	Co- Principal Investigator	
Dr. A. Mohan Rao	Male	Professor, Dept. of Genetics and Plant Breeding, UASB	Co- Principal Investigator	
Dr. M. Thippaiah	Male	Professor, Department of Agricultural Entomology	Co- Principal Investigator	
Dr. L. Vijaya Kumar	Male	Professor, Department of Agricultural Entomology, UASB	Co- Principal Investigator	
Dr. M.N. Thimmegowda	Male	Professor, Department of Agronomy, UASB	Co- Principal Investigator, (Activity 1a)	
Dr. Ashok H.G.,	Male	Professor, Department of Agricultural Engineering, UASB	Co- Principal Investigator	
Dr. Mudalagiriyappa,	Male	Chief Scientist, AICRP for Dryland Agriculture, UASB	Co- Principal Investigator	
Dr. K. G. Vijayalakshmi	Female	Professor, Department of Food Science and Technology, UASB.	Co- Principal Investigator	
Dr. Jayashree	Female	Assistant Professor, Department of Agricultural Engineering, University of Agricultural Sciences, Bangalore	Co- Principal Investigator	
Dr. R. L. Ravikumar	Male	Professor, Dept. of Plant Biotechnology, UASB	Co- Principal Investigator	
Dr. M. P. Rajanna	Male	Co- Principal Investigator And Specialist Officer, College of Agriculture, Chamarajanagar	Co- Principal Investigator And Specialist Officer	
Dr. Purnachandra Gowda	Male	Research fellow	Research Associate	
Dr. Sunitha N C	Female	Research fellow	Research Associate	

Dr. Vidyashree D. N.	Female	Research fellow	Research Associate	
Dr. Sharanappa Kuri	Male	Research fellow	Research Associate	
Mr. Lingaraju, N.N	Male	Research fellow	Senior Research Fellow	
Ms. Vedashree M S	Female	Research fellow	Senior Research Fellow	
Ms. Mounashree D. C.	Female	Research fellow	Senior Research Fellow	
Ms. Nethravathi L. M.	Female	Research fellow	Senior Research Fellow	
Ms. Vanishree	Female	Research fellow	Junior Research Fellow	
Mr. Mallikarjun Patil	Male	Research fellow	Junior Research Fellow	
Dr. Raghu R		Research fellow	Junior Research Fellow	
Ms. Meghana K J	Female	Research fellow	Junior Research Fellow	
Mrs. Sritama Kundu	Female	Research fellow	Junior Research Fellow	
Dr. Madhusudan N	Male	Research fellow	Junior Research Fellow	
Ms. Jyoti P Jirankali	Female	Research fellow	Junior Research Fellow	
Vinay Kumar B.	Male	Research fellow	Junior Research Fellow	
Ms. Anusha S. B.	Female	Research fellow	Junior Research Fellow	
Mr. Santosh Nagappa Ningoji	Male	Ph. D. Scholar	Junior Research Fellow	
Mr. Harishkumar T.G	Male	Ph. D. Scholar	Junior Research Fellow	
Mr. Vinod Godi	Male	Ph. D. Scholar	Junior Research Fellow	
Ms. Spoorthi		Ph. D. Scholar	Junior Research Fellow	
Ms. Gazala Parveen	Female	Ph. D. Scholar	Junior Research Fellow	
Ms. Shailja Chauhan,	Female	Ph. D. Scholar	Junior Research Fellow	
Mr. Shantaraja C. S.,	Male	Ph. D. Scholar	Junior Research Fellow	
Mr. Arun Kumar G Pandit,	Male	Ph. D. Scholar	Junior Research Fellow	
Ms. M. S. Ayesha Begum,	Female	Ph. D. Scholar	Junior Research Fellow	
Ms. Roopashree B.	Female	Ph. D. Scholar	Junior Research Fellow	
Ms. Hema Priya	Female	Ph. D. Scholar	-	
Tasmiya Imtiyaz	Female	Ph. D. Scholar	-	

Ms. Arya Sunil,	Female	M.Sc. (Agri.) Crop Physiology	-	
Ms. Yashaswini K. S.,	Female	M.Sc. (Agri.) Agricultural Microbiology	-	
Ms. Sowmyashree S.	Female	M.Sc. (Agri.) Agricultural Microbiology	-	
Mr. Kiran B. M.	Male	Ph. D. Scholar	Junior Research Fellow	
Ms. Jayashree A.		Ph. D. Scholar	Junior Research Fellow	
Mr. Shivakumara	Male	Ph. D. Scholar	Junior Research Fellow	
Mr. Honnakerappa Ballari,	Male	Ph. D. Scholar	Junior Research Fellow	
Mr. Vidyashankar,	Male	Ph. D. Scholar	Junior Research Fellow	
Ms. Sindhu, M. M.,	Female	Ph. D. Scholar	Junior Research Fellow	

6.2 Details of visits of PIU-NAHEP officials at your AU along with photographs (provide list)

 	Exhibition and Inauguration of CAAST-NGT_ Pest and Diseases forecasting portal at 107thIndian Science Congress (ISC)- 'Pride of India' at UAS, GKVK, Bengaluru from 3rd to 7th January 2020. *The Secretary (DARE) and Director General ICAR-New Delhi, Dr. Trilochan Mohapatra inaugurated the exhibition, and NC-NHAEP participated in the function.*
 	*The Secretary (DARE) and Director General ICAR-New Delhi, Dr. Trilochan Mohapatra examined the exhibition and reviewed the research and HRD activities of the ICAR-CAAST (NAHEP) project and released Central Instrumentation Facility brochures and laboratory manuals during his visit to UAS Bangalore.*
 	The Secretary (DARE) and Director General ICAR-New Delhi, Dr. Trilochan Mohapatra inaugurating the Central Instrumentation Facility in the presence of Hon'ble Vice- Chancellor UAS Bengaluru, Dr. S. Rajendra Prasad at North Block, UASB, GKVK Campus, Bengaluru on 20 March 2021.

* * *

Annexure

National Level training

HRD activities in the chosen areas

This program has a major mandate of imparting training to young faculty and Post Graduate (PG) students. A platform for training PG students has been created, and M.Sc. (Agriculture) and Ph.D. students working in these chosen areas are being trained in a well-organized manner. The Post Graduate students and young faculty of UASB were trained by inviting experts from different academic institutions and industries. Emphasis was also given for industry visits and field visits to expose the students to cutting edge technologies. Major workshops and hands-on experience under the CAAST project period are highlighted below.

Major workshop and hands-on training

Type of event	Title of event	No. of students participated	Host AU / Institute	Event duration (days)	Learnings
Workshop (National & International)	Hands on training on LC-MS/MS	22	UAS, GKVK, Bengaluru	4	Basics and operation of the LC-MS
	Hands on training Confocal Laser Scanning Microscope	15	UAS, GKVK, Bengaluru	2	Basics on microscopy and operation of Confocal microscope
	Hands-on Training on "Use of DNA markers in Crop Breeding"	26	UAS, GKVK, Bengaluru	10	Hands on experience on basic molecular biology (DNA extraction and PCR analysis)
	Agricultural Pest and Disease Simulation Modelling under a Climate Change Scenario	30	UAS, GKVK, Bengaluru	5	Advanced analytical tools / techniques used for agricultural pest and disease prediction models. Research data analysis to the Post Graduate students to equip with the skills. Participants were able use new tools for analysis

	Title of event	No. of students participated	Host AU / Institute	Event duration (days)	Learnings
	Hands-on Laboratory Course on CRISPR-Cas Gene Editing	33	UAS, GKVK, Bengaluru	5	Theoretical knowledge on the use of CRISPR-Cas technology; targeted gene editing
	Prequel to Plant Breeding by Design and Prediction	190	UAS, GKVK, Bengaluru	21	MAS and Genomic Selection approaches to enhance the pace and precision of developing improved cultivars by facilitating rapid genetic gain per breeding cycle
	Recent APMC act amendments in Karnataka - its implications	224	UAS, GKVK, Bengaluru	1	Sensitisation of the new APMC act too farming community
	Data Analytics using Advanced Excel/SPSS/R Interface for Postgraduate Students	28	UAS, GKVK, Bengaluru	5	Knowledge on advanced excel, SPSS and introduction to R programme helped the PG students & are now using these tools for analysing data
	Use of Advanced Tools in Pest and Disease Predictive Modelling	30	UAS, GKVK, Bengaluru	5	Enhanced the skills in advanced R programming for developing forecasting models, use of satellite weather data for use in forecasting and replacing old methods of analytical tools
	Advanced Analytical tools for pest and disease predictive models in R	23	UAS, GKVK, Bengaluru	8	Master trainers exposed to SAS and PYTHON for developing precise forecasting models

Thematic area specific trainings and workshops conducted during the project period

Reduced runoff farming

- Emerging Innovative Trends in Food Processing
- Climate Change: Concern for Food Security and Processing in India
- Next-Generation Technologies in Food Processing for Entrepreneurship Development
- Post-harvest technologies of fresh fruits and vegetables for commercial trade" at CSIR-CFTRI, Mysuru
- Application of Nanotechnology in Food and Agriculture" at Centre for Nanotechnology, UAS, Raichur
- Hi-tech Analytical instrumentation for agriculture and food product quality analysis" at NIFTEM, Thanjavur
- National level Workshop titled "Protected Cultivation Under Reduced Runoff Farming"
- International Workshop on "Groundwater Monitoring, Planning, Recharge and Sustainable Use: Village Level Participatory Approaches and Tools" conducted in collaboration with Western Sydney University, Australia
- Exposure visit to Madhavi Farms at Bannerghatta, Bangalore and Sula vineyard at Channapatna

National Workshop on Protected Cultivation Under Reduced Runoff Farming

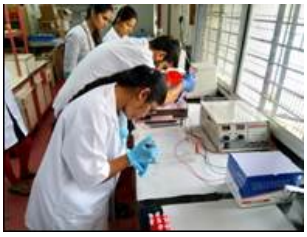
International Workshop on "Groundwater Monitoring, Planning, Recharge and Sustainable Use: Village Level Participatory Approaches and Tools

Students at Aquaponics unit of Madhavi Farms

Visit to Sula Winery, Channapatna

Precision crop breeding

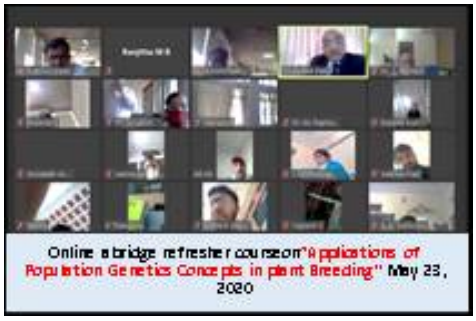
- Indian plant science congress held at SRM University Chennai - 23 to 25 January 2019
- DNA marker data analysis and its interpretation in crop improvement - 06 to 8th march 2019
- Principles and applications of genome editing for crop improvement - 09 to 13th May 2019
- Molecular Biology and Scientific Writing - 17 to 26th July 2019
- National workshop on digital field book - 7 August 2019
- Applications of SSR markers in Plant Breeding - 13 to 22th August 2019
- Plant genetic resource management and utilization organized by NBPGR New Delhi - 30th September to 11th October 2019
- Genomic assisted breeding for crop improvement organized by Division of genetics IARI New Delhi - 30th September to 12th October 2019
- Genome-wide QTL detection and prediction of breeding values for precision crop breeding - 27 November to 6th December 2019
- Predictive analytics for crop biology and breeding held on 4th March2020
- Recent APMC act Amendments in Karnataka – Its implications held on 23rd May 2020
- Practical experiences based IPR in commercial plant breeding during 26-27 June 2020
- Online abridge refresher course on "Applications of Population Genetics Concepts in Plant Breeding" during 27th July 2020 – 21st August 2020
- Prequels to Plant Breeding by Design and Prediction" from 18 January to 28 February, 2021
- Hands-on training on "Use of DNA Markers in Crop Breeding" from 12 to 21 March, 2021



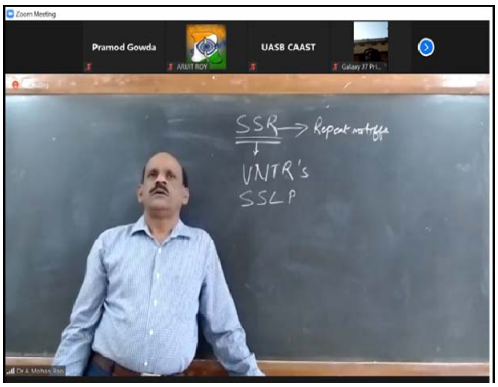
One day lecture workshop on "Predictive analytics for crop biology and breeding"

Online seminar on "Recent APMC act Amendments in Karnataka – Its implications" May 23, 2020

Online lecture series on "Practical experiences based IPR in commercial plant breeding" 26-27 June 2020



Online a bridge refresher course on "Applications of Population Genetics Concepts in plant Breeding" May 23, 2020



Exposure Visits

- Zonal Agricultural Research Station, Mandya, UAS, Bangalore
- East-West Seed Company, Bengaluru
- Monsanto India Pvt. Ltd, Kallinayakanahalli, Doddaballapura
- Zonal Agricultural Research Station, Mandya, UAS, Bangalore
- Education tour to Corteva Agriscience, Hyderabad and ICAR institutes in Hyderabad - 9 to 10 December 2019

Visit to i. Monsanto India Pvt. Ltd ii. East-West Seed Company iii. Zonal Agricultural Research Station, Mandya

Endophyte mediated modulation of crop growth and development

- Hands on Training on "Role of endophytes in modulating crop growth and development" conducted at the Dept. of Crop Physiology, UAS, GKVK, from 17-12-2018 to 22-12-2018 (Coordinator: Dr. Nataraja Karaba, Co-PI).

- Lecture workshop on "Role of endophytes in modulating crop growth and productivity: molecular mechanisms associated with plant- endophyte interactions" from 27-28 March 2019 (Coordinators: Dr. Nataraja Karaba, and Dr. N. Earanna)

- Public lecture on "Biotic and Abiotic Stress Tolerance in Plants: A Critical Aspects for Sustainable Agriculture" by Dr. Kirankumar Mysore, Professor, Nobel Research Institute, USA on 12 July 2019 (Coordinator: Dr. Nataraja Karaba, Co-PI).

- Tutorial on "Tips to Avoid Common Mistakes in Scientific Paper Writing" by by Dr. Kirankumar Mysore, Professor, Nobel Research Institute, USA on 17 July 2019 (Coordinator: Dr. Nataraja Karaba, Co-PI).

- Special lecture on 'Food Systems and Climate Change" by Dr. Neeraja Havaligi, UN Consultant, USA on 26 July 2019 (Coordinator: Dr. Nataraja Karaba).

- Lecture workshop on “Endophyte and their applications in agriculture” from 27-28 September 2019 (Coordinator: Dr. Nataraja Karaba, Co-PI).

- Lecture workshop on “Good laboratory practices and environmental safety” on 20 November 2019 (Coordinator: Dr. Nataraja Karaba).

- Hands on Training “Isolation and characterization of fungal endophytes” by Dr. Suryanarayanan, Director, VINSTROM, Chennai from 10-13 December 2019 (Coordinators: Dr. Nataraja Karaba, and Dr. N. Earanna)

- Lecture workshop on “Rapid method for screening of fungal endophytes for bioactive compounds” Dr. Suryanarayanan, Director, VINSTROM, Chennai from 20-23 January 2020 (Coordinators: Dr. Nataraja Karaba, and Dr. N. Earanna)

- Invited talk on “Dissecting the role of cuticular wax in plant resistance to multiple environmental stresses” and “Application of synchrotron technology in plant biology” by Dr. Karen Tanino Professor, University of Saskatchewan (UofS), Canada & Adjunct Professor, Dept. of Crop Physiology, UAS, GKVK, Bangalore, on 19 February 2020 (Coordinator: Dr. Nataraja Karaba)

- Invited talk on “Tre improvement towards low light tolerance: indoor citrus and other fruit tree breeding” by Mr. M.P.M. Nair, Indoor Lemon Tree Breeder, Grasswood, SK, Canada on 19 February 2020 (Coordinator: Dr. Nataraja Karaba)

- Invited talk on “R- are we Ready?’ by Dr. Sameer Joshi, Grains Innovation Park, Victoria, Australia dated on 20 February 2020 (Coordinators: Dr. Nataraja Karaba, and Dr. N. Earanna)

- Invited talk on “How endophytic fungi influence plant performance and ecosystem” by Prof. Ralf Ollemuller, Friedrich Schiller University Jena, Jena, Germany on 06 March 2020 (Coordinators: Dr. Nataraja Karaba, and Dr. N. Earanna)



Representative photographs offline training programs on endophyte-enrichment technology


Hands on training on microscopy


Training on "Good laboratory practices and environmental safety"


One-day lecture workshop on "LC/GC-MS/MS" was and over 200 PG students from 15 departments and staff members attended the workshop.

Online seminars/webinars

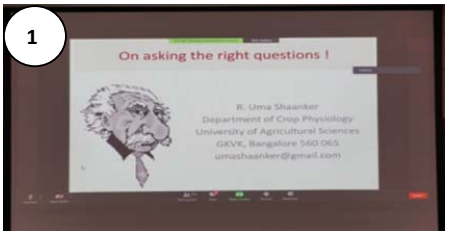
1. Online seminar on "On Asking the Right Question" by Dr. Uma Shaanker, ICAR Emeritus Scientist on 22nd of May, 2020. (Seminar Moderator: Dr. Nataraja Karaba)

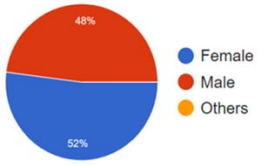
2. Webinar on the theme "How elementary statistics lead to major discoveries in biology" by Dr. Anil Gore dated 26th of May, 2020. (Seminar Moderator: Dr. Nataraja Karaba)

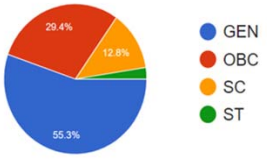
3. Online seminar on on "Publishing research papers in top journals: Why and How" by Yateendra Joshi on 2 June, 2020. (Seminar Moderator: Dr. Nataraja Karaba)

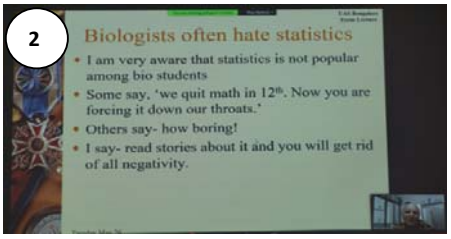
4. Webinar on Bamboos, Cicadas and Locusts -What binds them together? by Prof. K. Chanadrashekara on 9 June 2020. (Seminar Moderator: Dr. Nataraja Karaba)

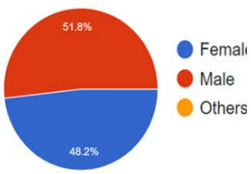
5. International webinar on “Endophytes and Climate Resilience in Plants” on 12 June 2020. (Seminar Moderator: Dr. Nataraja Karaba)
6. Hands on training on LC-MS/MS from 23.09.2020 to 26.09.2020 by Water’s application engineer. (Activity Moderator: Dr. Nataraja Karaba and Dr. N. Earanna)
7. Hands on training on Confocal Laser Scanning Microscope on 28.10.2020 by Leica engineer. (Activity Moderator: Dr. Nataraja Karaba and Dr. N. Earanna)

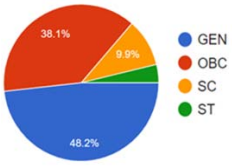


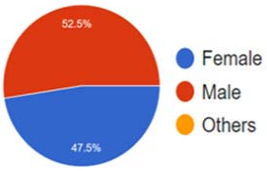


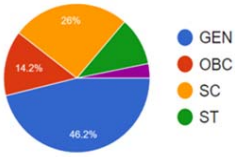












Forecasting pest and diseases

- Workshop on "Modeling and ICT applications in forecasting pest and diseases: Current status and emerging needs" on 12th and 13th of February 2019.
- Hands on Training on Nanopore sequencing on 17th and 18th of April 2019.
- Hands on training on Next Generation Disease Diagnostics on 20th to 29th of June 2019
- Hands-on workshop on Quant Studio qPCR techniques and exposure visit to Thermo Fisher Scientific, on 10th September 2019 at Whitefield, Bangalore
- Virtual Classes on Genome Assisted Diagnosis of Plant Viruses, Viroids and Phytoplasmas from 22nd& 23rd October 2019

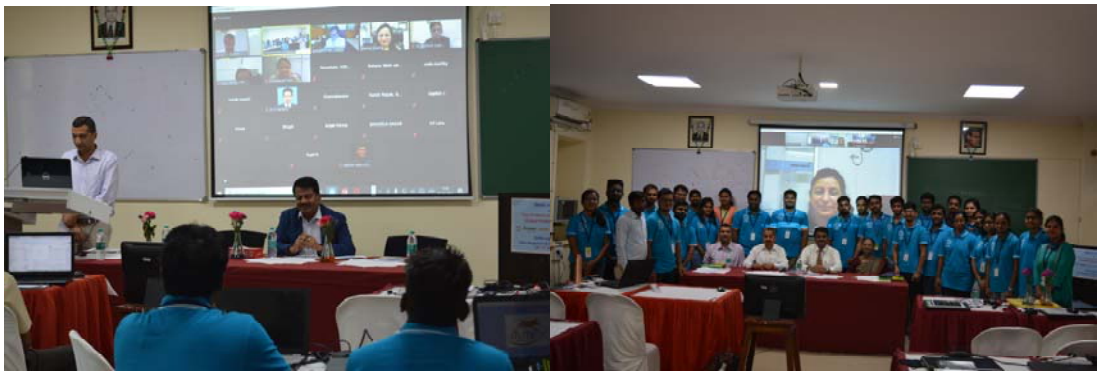
- Exhibition and inauguration of CAAST-NGT_ Pest and Diseases forecasting portal at 107th Indian Science Congress (ISC)- 'Pride of India' at UAS, GKVK, Bengaluru from 3 to 7 January 2020
- Short Course on Analytic Techniques for Pest and Disease Forecasting Models Dated from 08.01.2020 to 28.01.2020.
- Online hands on training on "Advanced Analytical tools for pest and disease predictive models in R" (Machine Learning Techniques) dated from 5th to 12th June 2020.
- Online expert workshop on Agricultural Pest and Disease Simulation Modelling under a Climate Change Scenario dated from 24-28th August 2020.
- Hands on Training on Use of Advanced Tools in Pest and Disease Predictive Modelling dated from 1-5th March 2021.
- Agricultural Pest Prediction and Advisory (APPA) Mobile App launched by DG (ICAR), At UASB dated on 20th of March 2021.
- Hands on Training on "Data Analytics using Advanced Excel/SPSS/R Interface for Postgraduate Students" dated from 23-27th March 2021.

Workshop on Modeling and ICT applications in forecasting pest and diseases: Current status and emerging needs

Glimpses of PPD training program: ***Group discussion of students with team leader at Hands on training on Next Generation Disease Diagnostics***

Exposure visit to Thermo Fisher Scientific- Hands on training on qPCR

Exhibition and Inauguration of CAAST-NGT_Pest and Diseases forecasting portal at 107th Indian Science Congress (ISC)- 'Pride of India' at UAS, GKVK, Bengaluru from 3rd to 7th January 2020



Hands on Training on Use of Advanced Tools in Pest and Disease Predictive Modelling

The Secretary (DARE) and Director General ICAR-New Delhi, Dr. Trilochan Mohapatra examined the exhibition and reviewed the research and HRD activities of the ICAR-CAAST (NAHEP) project and released Central Instrumentation Facility brochures and laboratory manuals during his visit to UAS Bangalore in March 2021.

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