ICAR-National Agricultural Higher Education Project

Project Report (up to December 31, 2023)

Component 1b: Centre for Advanced Agricultural Science and Technology (CAAST), Punjab Agricultural University

School of Natural Resources Management for Sustainable Agriculture

भाकृअनुप
ICAR

NAHEP

Punjab Agricultural University
Ludhiana – 141 004 (Punjab)
http://www.pau.edu

ICAR NAHEP CAAST

School of Natural Resources Management for Sustainable Agriculture

Project Report

(Up to December 31, 2023)

Punjab Agricultural University
Ludhiana-141 004, Punjab
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Executive summary

Name of the AU: Punjab Agricultural University, Ludhiana

Project Title: School of Natural Resources Management for Sustainable

Executive Summary:

The Project Monitoring Committee (PMC) of the NAHEP approved the "School of Natural Resources Management for Sustainable Agriculture" under NAHEP-CAAST with total cost of 1999.96 Lakh (Rupees one thousand nine hundred ninety-nine lakh and ninety-six thousand only) for a period of three years starting 2018-19 and ending 2021-22. School of Natural Resource Management for Sustainable Agriculture (CAAST-SNRM) at Punjab Agricultural University, Ludhiana focuses on reorienting the research agenda in favour of natural resource conservation by tapping into interdisciplinary synergies through integrating aspects of nutrient and water management, agronomic practices, appropriate farm mechanisation and varietal component.

Created opportunities for Master and PhD students to imbibe and integrate interdisciplinary approaches related to NRM for sustainable intensive agriculture in their research programmes. Four courses on NRM for PG students were formulated. Courses are - Recent Techniques in Crop Residue Management vis-a-vis Soil Quality; Integrated Management of Water Resources; Natural Resources Management under Climatic Variability; Environmental Pollution and Management involving knowledge and technology updates, and interdisciplinary synergies in emerging areas of NRM for PG Students. Capacity building of faculty through training at advanced centres and International Institutes in cutting edge areas of NRM namely artificial intelligence (drone technology, robotics), climate smart agriculture, sensor-based nutrient and water management. Thirteen PhD students & fourteen faculty members from different departments associated with CAAST project selected for foreign trainings. However due to COVID epidemic only five PhD students & two faculty members completed their foreign training. Workshops/Seminars/Distinguished Guest Lecture Series/Specialised training programs on innovative NRM technologies, climate resilient agriculture and precision farm mechanizations were organised. Lectures by distinguished visiting professors from reputed international institutes/universities were organised on specific topics related to NRM (Need- and Sensor-based N management, precision agriculture including robotics and drones, RCT & CRM, Climate Change driven NRM, Automation and micro-irrigation systems and CRM driven selection/breeding of crop cultivars). Laboratories were upgraded with latest equipment/machinery & software. Research activities were taken up as per the objectives. Quality research papers on NRM were published in high impact factor journals. Industry-Institute interface & student Internships for training/mentoring of students in cutting-edge areas of NRM were organised.

Introduction

The agriculture system in the food basket of the India (Punjab, Haryana and Western UP) has undergone successive intensification, for instance the cropping intensity has reached to 209% in Punjab state. Much of the agricultural research and development has been conducted in the green revolution productivity oriented paradigm. The adverse effects on sustainability of the natural resource base are evident and well documented. There needs to reorient the research agenda in favour of natural resource conservation by tapping into interdisciplinary synergies. Agro-technological packages must integrate aspects of nutrient and water management, agronomic practices, appropriate farm mechanization and varietal component. The integrative research agenda can only be fulfilled through forging new connections across disciplinary boundaries and devising an enabling system of higher learning and training. The proposed CAAST focuses on mitigating negative fallouts of the intensive rice-wheat based system while sustaining its productivity.

As we envisage these transitions we look forward to the younger generation who can provide the vital spark for the required changes. Postgraduate research and training represent a point of far-reaching intervention in this regard with an inbuilt multiplier effect.

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

1.1. Interventions carried out by AU which helped to improved research effectiveness

Please provide the details about the interventions carried out to make AU reform ready and led to ICAR accreditation. Please write one paragraph for each intervention and/or activities.

Key interventions	*Remarks/Photographs*
Post Graduate Course on Natural Resources Management (Annexure Ia)	***NRM 501*** *Recent Techniques in Crop Residue Management vis-a-vis Soil Quality (2+1)* ***NRM 502*** *Integrated Management of Water Resources (2+1)* ***NRM 503*** *Natural Resources Management under Climatic Variability (2+0)* ***NRM 504*** *Environmental Pollution and Management (2+0)*
Laboratories were updated with latest & advanced equipment & machinery	*The upgrade includes High precision analytical electronic balance, Soil moisture sensors, Gas chromatography mass spectrometry machine, Pressure plate, Incubator, Hot air & microwave ovens, Spectrophotometer, Flame photometer, Autoclaves, Yoder's apparatus, Saturated hydraulic conductivity meter, Water bath, Incubator, Sonicator, Horizontal electrophoresis apparatus,*
Farm Machinery were improved i.e. paddy transplanter, smart seeder, baler (Annexure Ib)	• *A* ***straw combine was modified for harvesting and chopping of paddy straw****.* • *A prototype of electronic metering mechanism for* ***liquid urea*** *has been developed. Development for liquid urea application is under progress.* • *Design of the* ***mechanical-cum-spray weeder*** *has been made.* • ***Baling system*** *has been mounted with combine harvester. Flat belt conveyor system was developed and selected for conveying the loose paddy residue falling from straw walker to the feeder assembly of the baling attachment.*
PAU Urea guide App (Annexure III)	Urea guide in Hindi, Punjabi and English language for farmers to advise them about the Urea dosage required for their crop using the Leaf Color Chart and Greenseeker
PG student & faculty were sent for international training	*Nine students & eleven faculty members were sent for international training to distinguished universities abroad*
Distinguished lecture series - 07 lectures (Annexure Ic)	The university hosted a remarkable 'Distinguished Lecture Series', featuring renowned scholars and experts. A total of seven lectures were arranged as part of the series.
Publications > 7 NAAS Rating (Annexure II)	*>7.0 NAAS rating - >50* *>8.0 NAAS rating - 38* *> 9.0 NAAS rating - 31* *> 10.0 NAAS rating - 12*

MOUs were signed with different industries/universities/Institutions	Seven MOUs were signed with various industries, universities, and institutions, promoting collaboration and partnership, and providing opportunities for joint projects and initiatives.

1.2. How the facilitative units helped to enhance learning outcomes

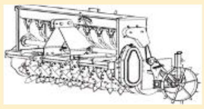
Please provide the details of the facilitative units which helped in enhancing learning outcomes of the students and/or faculties. Please note that we may not need to mention all facilitative units created in the AU here, but focus on those which are open for the students/faculties and other stakeholders.

Facilitative unit	***Activity/achievement***	***Remarks/Photographs***
Establishment of GIS Laboratory	This lab is equipped with software like ESRI ArcGIS, ENVI for Geoinformatics studies; HYDRUS 3D model model for simulating water, heat, and solute movement in saturated media; and other cropping system models for studying varying issues related to NRM	
Strengthening of Precision Agriculture Lab in the Department of Farm Machinery & Power Engineering		
Refurbishment of Laboratories	The refurbishment of research laboratories was done with the latest and advanced equipment & machinery to optimize the academic experience & create state-of-the -art space for both PG students & faculty members	
Smart Classrooms	The implementation of smart classrooms allows to use a variety of multimedia materials through the use advanced digital tools such as multimedia projectors and other digital tools to supplement their lectures	

1.3. *Out-of-box initiatives undertaken by the AU*

Please provide the details on out-of-box initiatives undertaken by the AU in one-two paragraph.

Out-of-box initiative	***Activity/achievement***	***Remarks/Photographs***
Autonomous Paddy Transplanter in Puddled Field	***Patent filed: 01*** *An Autonomous System for 2-Wheel Paddy Transplanter.* *Patent Application No. : 202111019252*	

PAU Urea Guide Mobile App	Urea guide in Hindi, Punjabi and English language for farmers to advise them about the Urea dosage required for their crop using the Leaf Color Chart and Greenseeker	
Spraying with drone	Investigate different design and operations parameters of selected nozzles to reduce drift during spraying with drone.	
Production of Biochar from surplus biomass	A **pyrolysis plant** was established at PAU Ludhiana for the biochar production from surplus biomass. Biochar is being produced through intermediate pyrolysis at 450-500 °C without escape of bio-oil or gases to the atmosphere.	
PAU Smart Seeder	*The PSS combines the positive effects of both the processes of incorporation and surface retention of residues in one machine; therefore, the fuel consumption of PSS was observed to be intermediate between that of Happy Seeder and Super Seeder. The PSS incorporates only a small part of the straw in the soil and retains the majority of straw as surface mulch due to this the chances of seeds dropping on straw are lesser. Wheat emergence was higher by 15.6 and 25.7% on the PSS plots compared with HS and SS, respectively.*	 
Rectangular straw baler	The wheat sowing with zero till drill will be done easily after the paddy harvesting with this baling attached self-propelled combine harvester as standing paddy stubbles will not create any hindrance to the wheat sowing operations. This technology will be helpful for effective management of loose paddy residue coming out from the conventional combine harvester.	
Soil Moisture Sensor System	*The soil moisture module consists of capacitive moisture sensor which uses capacitive sensing to detect soil moisture. The low cost sensor system conceptualized, developed and evaluated that was compared with the commercially available sensors and found to be at par in moisture prediction. Therefore, the low cost sensor system can be used at farmers field for precise application of water.*	 

1.4. Collaborations with industry and other HEIs for bringing relevancy

1.5. Relevant collaboration with industry for bringing relevancy and improving research effectiveness in the AU in one-two paragraph.

Collaborations	*Activity/achievement/purpose*	*Remarks/Photographs*
Mahindra Research Valley, Chennai	Development of advanced Farm Machinery	Project work/ Internship
Advance Tech, Chandigarh	Automatic wireless weather station	Precision farming
Thapar University, Patiala	Collaborative Research	Project work/ Internship
John Deere India	To establish Farmers Training Centre at PAU	Training of Farmers on Farm Machinery issues
More than 30 agro-industries for commercialization of machinery	For crop residue management	Resources conservations
Semi-Conductor Laboratory (SCL) Mohali	Human Resource Development	Project work/ Internship
FRI Dehradun	For teaching Research and Extension education	Resources conservations

2. Achievements made through CAAST under NAHEP

2.1. Output-outcome monitoring

S. N.	Particulars	Apr'2018 to Dec'2023	
		Target	Achievement
1.	% increase in number of technologies commercialized	-	08
2.	% increase in faculty research effectiveness		17 (H index)
3.	Number of direct beneficiaries of the project		200
4.	Number of female beneficiaries		40% (11th AHEPC)
5.	% increase in JRF / SRF / ARS		
6.	% increase in number of students who were admitted in foreign universities		
7.	% increase in PG student placements		17%
8.	Number of industry- sponsored projects and positions in cutting-edge areas of agri-science		-
9.	Number of faculty training programmes (national) undertaken by AU	25/10	
10.	Number of faculty training programmes (international) undertaken by AU	14	12
11.	Number of student training programmes (national) undertaken by AU	22/20 (from EAP report)	
12.	Number of student training programmes (international) undertaken by AU	13	09

Observation

International training of students and faculties provide new platform where students/faculties can drive new interest, collaborative projects and enhance their vision. Student and faculty are not only got to learn about the subject but also got look at thinks from perspective.

2.2. Knowledge Management Collaterals

I. Knowledge Collaterals	Apr'2018 to Mar'2023
1. Publications	
2. Research Articles	>50 (NAAS Rating – 7 or above) (Annexure II)
3. Annual Reports	03
4. Practical manuals	02
5. Books	-
6. Success Stories	07
7. Newsletter	-
8. Magazines	02 (Training Manual)
9. Blogs	-

II. Mobile and Web Applications	Apr'2018 to Mar'2023
1. Mobile Applications Developed	01 (Annexure III)
2. Web Applications Developed	-

III. Number of IPR (Intellectual Property Rights) Registered/Obtained	Apr'2018 to Mar'2023
1. Copyrights	
2. Patents	01 (Annexure IV)
3. Others	

IV. Dissemination and Outreach	Apr'2018 to Mar'2023
1. No. of Posts on Social Media	
2. No. of Posts on Newspaper	
3. No. of Posts on Magazines	
4. No. of Unique Promotional or Outreach Collaterals	

2.3. Capacity building programs to improve the research effectiveness

1. **International trainings for students and faculties- Annexure V**

Subject areas	*Host institutes, period of training*	*Output of the training*
Students		
Ms. Gargi Sharma	***Mentor & Institute of Training:*** *Dr Sharon Benes* *California State University, Fresno, USA* ***Duration:*** *February 18 to July 1, 2020*	*Task was to optimize the extraction and analysis protocols for measuring sodium, potassium and boron in alfalfa shoot tissue. This involved learning the microwave acid digestion process and detection using an MP-AES (microwave plasma atomic emission spectrometer). On the detection side, optimization involved determining the best measurement wavelength and working range for each element, the proper number and range of standards and determination of the percent error in the measurement through comparison to known standards.*
Mr. Shiv Kumar Lohan	***Mentor & Institute of Training:*** *Prof Manoj Karkee, Associate Professor, Biological Systems Engineering Center for Precision and Automated Agricultural Systems, Washington State University, Prosser, USA* ***Duration:*** *March 16 to August 15, 2020*	*Objective was to develop integrated robotic system for green shoot thinning of vineyard grapes. Under this object, a prototype platform using automatically controls the position and orientation of thinning end- effector (flappers) to follow the cordon trajectories were designed and developed on the basis of previous studies using semantic segmentation-based machine vision systems and deep learning networks. An overview of various hardware machines and equipment of the centre were observed during the training programme.*
Ms. Jyolsna T	***Mentor & Institute of Training:*** *Dr DJ Mulla* *Professor and W.E. Larson Chair for Soil and Water Resources* *Dept. of Soil, Water & Climate, University of Minnesota, St. Paul, MN* ***Duration:*** *February 18 to July 1, 2020*	*Learned some basic GIS tools like how to create a map and analyze mapped information. A simulation study using HYDRUS 1D model was conducted to evaluate the impacts of nitrogen and irrigation management on potato at a Minnesota*

		experimental site near Becker. HYDRUS-1D model used to simulate the water and nitrogen movement in the soil profile.
Mr. Susanta Das	***Mentor & Institute of Training:*** *Dr Jonathan Aguilar, Associate Professor Department of Biological and Agricultural Engineering Kansas State University, Manhattan, KS* ***Duration:*** *January 3rd, 2022 to March 18, 2022*	*Learned about different Soil moisture and temperature sensors, HYDRUS 1D model, canter pivot irrigation system and UAV image analysis for irrigation scheduling*
Ms. Manjeet Kaur	***Mentor & Institute of Training:*** *Dr Rattan Lal Carbon Management and Sequestration Centre (CMASC), The Ohio State University, Columbus, USA* ***Duration:*** *March 12, 2020 to July 18, 2020*	*A short study was conducted at Waterman Field to know the effect of compost amendment on greenhouse gas emissions. The collected gas samples were analyzed for CO_2, N_2O and CH_4 concentrations using Gas Chromatograph and soil samples were analyzed for different carbon fractions.*
Ms. Raagjeet Kaur	***Mentor & Institute of Training:*** *Dr Francesca Coturfo, Professor, Dept. of Soil and Crop Sciences, Colorado State University, Fort Collins, USA* ***Duration:*** *March 15, 2020 to July 17, 2020*	*Engaged in laboratory activities and gained experience on the size and density fractionation of organic matter into Particulate organic matter and Mineral-associated organic matter (light and sand-sized, silt-sized and clay-sized fraction), soil preparation for PLFA analysis, worked with carbon and nitrogen isotopes enriched rhizospheric soil samples from an incubation study in Kansas and other things like soil processing and root extraction.*
Mrs. Amina Raheja	***Mentor & Institute of Training:*** *Dr Jasmeet Judge, Professor Agricultural and Biological Engineering, University of Florida, Gainesville, FL 3261, USA* ***Duration:*** *February 7, 2022 to March 28, 2022*	*Basic of GIS tools for Land use classification using Remote Sensing Techniques and Capacitance based sensors for monitoring soil moisture*
Ms. Padma Angmo	***Mentor & Institute of Training:*** *Dr Javed Iqbal, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln NE, USA* ***Duration:*** *February 8 to March 28, 2022*	*Learnt new techniques for nitrification and soil column study by microplate method and the microplate methods can be also used in soil enzyme studies. Also learned about Phospholipids fatty acid extraction, Microbial biomass Carbon and Nitrogen, Hot-water extractable, and cold-*

		water extractable carbon for soil analysis
Ms. Tarandeep Kaur	***Mentor & Institute of Training:*** *Dr Tarlok Singh Sahota, Director* *Lakehead University, Delta Research & Extension Centre* *Stoneville, Mississippi State University, Mississippi, USA* ***Duration:*** *March 1st 2022 to March 31st 2022*	*Learned whinrhizo root scanner and tactics of operating growth chambers. Also, gained knowledge about SAS statistical software and sigma plot.*
Faculty		
Dr. GS Dheri	***Mentor & Institute of Training:*** *Dr Rattan Lal, Professor* *Carbon Management and Sequestration Centre (CMASC)* *The Ohio State University, Columbus, USA* ***Duration:*** *March 16, 2020 to September 13, 2020*	*This training programme helped to gain experience of the latest technologies for conducting virtual classes, meeting and seminars. Got hands-on working experience of Gas Chromatograph, Photoacoustic greenhouse gas analyzer and CHN analyzer, profile bulk density sampler, automated penetrometer during the training programme*
Dr. Manjeet Singh	***Mentor & Institute of Training:*** Dr. Asim Biswas*, School of Environmental Sciences* *University of Guelph, 50 Stone Road East, Guelph, ON* ***Duration:*** *December 01, 2021 to January 31, 2022*	*Training on proximal soil sensing; sensor-based soil characterization and crop management decision making; and integrating proximal and remote sensing data including drones in crop management decision making.*
Dr. Varinderpal Singh	***Mentor & Institute of Training:*** *Dr William R. Horwath, Chair & Professor of Soil biogeochemistry* *Deptt. of Land, Air and Water Resources* *University of California, Davis, USA* ***Duration:*** *January 7, 2022 to March 25, 2022*	*Training on Precision Nutrient Management during his interactions with the scientists at UC, Davis, California state University, Fresno and A&M University, Texas.*
Dr. Simerjeet Kaur	***Mentor & Institute of Training:*** *Dr Mithila Jugulam* *Department of Agronomy* *Kansas State University, Manhattan, USA* ***Duration:*** *December 5, 2021 to February 4, 2022*	*Weed Physiology, Herbicide Absorption and Translocation Studies, Seed Production of Resistant Biotypes*
Dr. Samanpreet Kaur	***Mentor & Institute of Training:*** *Dr Asim Biswas* *Associate Professor and Graduate Program Coordinator* *School of Environmental Sciences* *University of Guelph, 50 Stone Road East, Guelph, ON* ***Duration:*** *December 17, 2021 to March 17, 2022*	*Use of Satellite/Sensor data for Sustainable Management of Water Resources in Agricultural Landscapes*

Dr. B.B. Vashisht	***Mentor & Institute of Training:*** *Dr. D.J. Mulla, Professor* *Department of Soil, Water and Climate, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota, Twin Cities Campus, St. Paul, MN* ***Duration:*** *February 16, 2022 to March 24, 2022*	*Training on soil water transport modeling using Hydrus-1D* *Learned estimation of infiltration, percolation, solute transport and changes with depth and time in soil moisture content, soil matric potential, and solute concentration*
Dr. Manpreet Singh	***Mentor & Institute of Training:*** *Dr. Tom Burks* *Professor, Robotics, Machine Systems & Automation* *Department of Agricultural & Biological Engineering, University of Florida, USA* ***Duration:*** *January 2022 to March, 2022*	*Image processing for Real time weed detections and spraying*
Dr. Ajmer Singh Brar	***Mentor & Institute of Training:*** *Engineering Systems and Environment 151 Engineers Way PO Box 400747, Olsson Hall Room 102E* *University of Virginia, Charlottesville V A, 22904* ***Duration:*** *March 12, 2022 to March 28, 2022*	*Assessment of soil moisture through remote sensing and validation through in-situ data*
Dr. M.S. Mavi	***Mentor & Institute of Training:*** *Dr Steven Hall* *Department of Ecology, Evolution, and Organismal Biology* *Iowa State University* *245 Bessey Hall, Ames 50011, USA* ***Duration:*** *June 15 -September 14, 2022*	
Dr. O.P. Choudhary	***Mentor & Institute of Training:*** *Dr Stephen R Grattan University of California, Davis, USA* ***Duration****: July 05-August 18, 2022*	*Exploring research and teaching collaborations with Dept of Land, Air and Water, UCD, Davis on sustainable nutrient and water management*
Dr. Sandeep Sharma	***Mentor & Institute of Training:*** *Dr. Javed Iqbal* *Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln NE, USA-68583* ***Duration:*** *September 12- November 13, 2022*	*Training on microplate method for nitrification and soil enzyme assay. Learned new technique for estimation of soil structural organic matter and phospholipids fatty acid extraction analysis*
Dr. Rakesh Sharda	***Mentor & Institute of Training:*** Dr. Ramesh Rudra Professor Water Resources Engineering School of Engineering University of Guelph Ontario, Canada N1G 2W1 ***Duration:*** *March 14- March 2 1, 2022*	

2. National trainings for students and faculties- Annexure VI

Subject areas	*Period of training, total beneficiaries*	*Output of the training*
Students		
Ms. Jyolsa T., a PhD student of Deptt of Soil Science attended a, jointly organized by University of California, USA and IIT Mandi at IIT Mandi	*September 9-11, 2019*	*Specialized training on Applications of HYDRUS model*
Ms. Amina Raheja had undergone training on at Jamiia Millia Islamia University, New Delhi	*January 27-February 27, 2020*	*Development of capacitance based sensor Soil Moisture Sensor*
Mr. Susanta Das had undergone training on at Jamiia Millia Islamia University, New Delhi	*January 27-February 27, 2020*	*Development of capacitance based sensor Soil Moisture Sensor*
Mr. Shiv Kumar Lohan, a PhD student of Deptt of Farm Machinery & Power Engineering visited Central Institute of Agricultural Engineering, (CIAE), Bhopal	July 04-05, 2019	*To study the measurement actuating force on the hand levers of farm machineries & IIT Kharagpur*
Mr. Shiv Kumar Lohan, a PhD student of Deptt of Farm Machinery & Power Engineering visited to IIT Kharagpur	July 21-22, 2019	Learning the installation of electronic actuators to control the hand levers of tractors and other farm machineries
Faculty		
Dr. B.B. Vashisht, Principal Soil Physicist-cum-Co PI, NAHEP CAAST, attended one day training at Division of Agricultural Physics, IARI, New Delhi	*September 09, 2020,*	*Drone remote sensing in agriculture*
Dr. B.B. Vashisht, Principal Soil Physicist-cum-Co PI, NAHEP CAAST, attended one day training at Division of Agricultural Physics, IARI, New Delhi	*December 08, 2021*	*Modelling soil physical processes for improving resource use efficiency in agriculture*

2.4. Input and activity monitoring

	Capital	Revenue
Total funds sanctioned during 2018-2023 by PIU (INR Lakhs)	705.94	1394.02
Total funds received till March 31, 2023 (Cumulative) (INR Lakhs)	705.94	1394.02
Total expenditure up to March 31, 2023 (INR Lakhs)	705.87	1392.33

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	278.18		
	Office equipment	8.30		
	Laboratory equipment	279.2		
	Furniture & fixtures	16.64		
	Computers and Peripherals	19.51		
	Books and Journals	16.64		
Civil works	Minor repair and renovation work	87.40		
Human capacity building	National level training	-		
	International level training	62.28		
	Short visit/ seminars	12.84		
	Meetings and workshops	8.02		
Consultancy	National level consultancies	87.39		
Recurrent cost / Miscellaneous	Travel	11.75		
	Contractual services	267.79		
	Operational costs	880.78		
	Institutional charges	61.48		
Total		**2098.2**		

2.5. 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.)

Illustrative: Success story

1. Autonomous Paddy Transplanter in Puddled Field

The prototype of remotely controlled system has been designed and developed for walk behind type paddy transplanter to reduce the physical and psychological workload of operator. The increase in effective field capacity was observed up to 20%, resulting the net benefit per unit area and per year has been increased by 6.6% and 15.9% respectively. The overall results of the field evaluation showed that the remote-controlled system for two-wheel paddy transplanter would be feasible at optimized field and machine parameters.

The preliminary laboratory and field testing have been completed.
Fine tuning, modifications and field experiment of the developed system is under progress.

Patent filed: 01
An Autonomous System for 2-Wheel Paddy Transplanter.
Patent Application No.: 202111019252

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.)

Illustrative: Success story

2. PAU Urea Guide Mobile App

A decision support system for need-based fertilizer N use in field crops. The adoption of the PAU-Urea Guide App based N management practices will substantially reduce the fertilizer N use, increase farmers' income, reduce insecticide and pesticide consumption while mitigating air and water pollution and saving exchequer of government from huge subsidy on N fertilizer.

No of Downloads - 5T+
Link - https://play.google.com/store/apps/details?id=com.pau.soils&hl=en_IN

Urea guide in Hindi, Punjabi and English language for farmers to advise them about the Urea dosage required for their crop using the Leaf Color Chart and Green seeker

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.)

Illustrative: Success story

3. Production of Biochar from surplus biomass

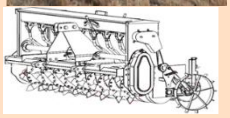
A pyrolysis plant was established at PAU Ludhiana for the biochar production from surplus biomass. Biochar is being produced through intermediate pyrolysis at 450-500 °C without escape of bio-oil or gases to the atmosphere.

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.)

Illustrative: Success story

4. PAU Smart Seeder



The PSS combines the positive effects of both the processes of incorporation and surface retention of residues in one machine; therefore, the fuel consumption of PSS was observed to be intermediate between that of Happy Seeder and Super Seeder. The PSS incorporates only a small part of the straw in the soil and retains the majority of straw as surface mulch due to this the chances of seeds dropping on straw are lesser. . Wheat emergence was higher by 15.6 and 25.7% on the PSS plots compared with HS and SS, respectively.

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.)

Illustrative: Success story

5. Rectangular straw baler

The wheat sowing with zero till drill will be done easily after the paddy harvesting with this baling attached self-propelled combine harvester as standing paddy stubbles will not create any hindrance to the wheat sowing operations. This technology will be helpful for effective management of loose paddy residue coming out from the conventional combine harvester

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.)

Illustrative: Success story

6. Soil Moisture Sensor System

The soil moisture module consists of capacitive moisture sensor which uses capacitive sensing to detect soil moisture. The low cost sensor system conceptualized, developed and evaluated that was compared with the commercially available sensors and found to be at par in moisture prediction. Therefore, the low cost sensor system can be used at farmers field for precise application of water.

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.)

Illustrative: Success story

7. Spraying with drone

Investigate different design and operations parameters of selected nozzles to reduce drift during spraying with drone.

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

S.N	Category of the collateral	Brief summary	Snapshot/cover page	Weblink (if any)
1	Website- NAHEP CAAST SNRM			http://www.nahep-caast-pau.com/

c) Unique initiatives undertaken

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.)

Web Cameras, Flat Panel-Touch Interactive, Multimedia projectors

Smart Classrooms fitted with Flat Panel-touch screen, multimedia, web cameras were developed

2. Digital initiatives:

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

S.N	Category of the collateral	Digital initiative	Practice before introduction of the initiative	Practice after introduction of the initiative
1	**Online Trainings**		All training sessions were held in person	Training sessions were shifted to an online platform
		Ecosystem Services of Forest Plantations and Agroforestry Systems on Jan 25, 2022		
		Soil-centric Green Revolution: A Paradigm Shift by Dr Rattan Lal, World Food Prize Laureate on Aug 19, 2020		

		Challenges and Opportunities of Adopting Direct Seeded Rice by Dr Gurdev Singh Khush, renowned Rice Breeder & 1996 World Food Prize Laureate on Sept 23, 2020		
		Automation and Robotics in Agriculture (International) on July 22-31, 2020		
		Drip Irrigation and Fertigation Management on June 15-23, 2020		

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. Also, relate how input turned into output→outcome→impact in brief sentence or graphical way. Consider one or two examples/cases etc,

NOTIFICATION FOR INCLUSION OF SMART SEEDER IN THE SUBSIDY SCHEME OF GOVERNMENT OF INDIA

F. No 13-1/2020- M&T (I&P) (Part IV) (87948)
Government of India
Ministry of Agriculture and Farmers Welfare
Department of Agriculture and Farmers Welfare
(Mechanization & Technology Division)

Krishi Bhawan New Delhi,
Dated 8th September, 2022

Subject: Inclusion of Smart Seeder Machine for financial assistance under Crop Residue Management Scheme - Regarding

The undersigned is directed to inform that, the request received from the Directorate of Research, Punjab Agricultural University, Ludhiana to include Smart Seeder for financial assistance under the Crop Residue Management (CRM) Scheme has been examined in this Department in consultation with the State Agriculture Departments. The Smart Seeder machine is already included for financial assistance under Sub-Mission on Agricultural Mechanization (SMAM) as the pattern of assistance as indicated below:

S. No.	Type of Agricultural Machinery	For SC, ST, Small & Marginal farmers, Women and NE States beneficiary		For other beneficiary	
		Maximum permissible subsidy per Machine/ Equipment per beneficiary inclusive of GST @ 12% (Rs.)	Pattern of assistance	Maximum permissible subsidy per Machine/ Equipment per beneficiary inclusive of GST @ 12% (Rs.)	Pattern of assistance
I	**Smart Seeder**				
	09 tine	0.740 lakh	50%	0.592 lakh	40%
	10 tine	0.765 lakh		0.612 lakh	
	11 tine	0.785 lakh		0.628 lakh	
	12 tine	0.820 lakh		0.656 lakh	

The competent authority of this Department has recommended that the States may extend financial assistance to the farmers and CHCs for purchase of Smart Seeder machines as per their choice and as per the pattern of assistance as already approved under the CRM Scheme. The maximum permissible assistance for individual purchase of Smart Seeder machine as per the pattern of assistance of CRM scheme may be as under:

S.No.	Name of the machine/equipment	Maximum permissible subsidy per Machine/ Equipment per beneficiary inclusive of GST @ 12% (Rs.)	Pattern of Assistance
1.	**Smart Seeder**		
	a) 09 tine	74,000	50%
	b) 10 tine	76,500	50%
	c) 11 tine	78,500	50%
	d) 12 tine	82,000	50%

This is issued with the approval of competent authority of this Department

(Arvind Meshram)
Deputy Commissioner (M&T)
Tele: 011-23382922
Email: arvind.meshram@gov.in

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

Challenges	
1	Foreign trainings of 10 scientists and 15 students associated with the CAAST project cleared and cases processed, but deferred due to COVID-19.
2	The lockdown due to COVID19 coincided with the harvesting of *rabi* season crops (wheat, mustard and rabi pulses etc.) and sowing/transplanting of kharif crops (maize, cotton and rice etc.). Different field observations (periodic measurements) other than yield and soil and plant samples couldn't be taken extensively due to restrictions and inadequate labour availability.
3	Laboratory work also suffered a lot. However, partial laboratory analyses resumed from June, 2020.
Lessons learned	
1	The importance of having contingency plans in place to deal with unexpected situations was highlighted.
2	The need for digital communication tools and virtual collaboration platforms was emphasized, as these helped to bridge the communication gap during the lockdown period. or The pandemic highlighted the need for greater investment in technology and digital skills training for faculty and students.

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? Yes*

1	Consultancy
2	Soil & water testing - Offering precise soil, water and plant analyses using state-of the art laboratory facilities/equipment for all the stake holders for nutrition and pollution assessment
3	Writing grant funding proposal

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

1	Facilities established under NAHEP-CAAST Project i.e. upgraded laboratories, farm machineries, software-Cropping System Models, Arc GIS, ENVI, Hydrus etc., audio-video aids will be used for future research issues on NRM by faculty as well as PG students
2	Nominal fee will be charged from other government/semi-government as well as private agencies for use of established facilities.

6. Contribution of each individual in project

6.1. Name of Vice Chancellors(s) during project duration and contributions 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.)
Dr. Satbir Singh Ghosal	Male	Vice-Chancellor	Head of the Institution
Dr. Baldev Singh Dhillon	Male	Former Vice-Chancellor	Head of the Institution
Dr. Dhanwinder Singh		Head, Department of Soil Science dhanwinder@pau.edu	PI
Dr. O.P. Choudhary	Male	Principal Soil Chemist opchoudhary@pau.edu	PI (up to Oct, 2023)
Dr BB Vashisht	Male	Principal Soil Physicist bharatpau@pau.edu	Co-PI
Dr. M.S. Mavi	Male	Principal Soil Chemist mavims16@pau.edu	Co-PI
Dr Sandeep Sharma	Male	Microbiologist (Soils) sandyagro@pau.edu	Co-PI
Dr Varinderpal Singh	Male	Principal Soil Chemist singhvp72@gmail.com	Co-PI
Dr GS Dheri	Male	Principal Soil Chemist gsdheri@pau.edu	Co-PI
Dr Manjeet Singh	Male	Principal Scientist (FMPE) manjeetsingh_03@pau.edu	Co-PI
Dr Ajmer Singh Brar	Male	Principal Agronomist braras@pau.edu	Co-PI
Dr G.S. Mangat	Male	Principal Rice Breeder gsmangat-pbg@pau.edu	Co-PI
Dr. Renu Khanna	Female	Rice Breeder renukhanna-pbg@pau.edu	Co-PI
Dr Samanpreet Kaur	Female	Associate Professor samanpreet@pau.edu	Co-PI
Dr Manpreet Singh	Male	Extension Scientist (FMPE) msbham@pau.edu	Co-PI
Dr Simerjeet Kaur	Female	Principal Agronomist simer@pau.edu	Co-PI
Dr Sanjeev Kumar Chauhan	Male	Professor chauhanpau@pau.edu	Co-PI
Dr Sunil Garg	Male	Principal Scientist Sunil1765@pau.edu	Co-PI
Dr KG Singh	Male	Senior Research Engineer	Co-PI
Dr Rakesh Sharda	Male	Principal Scientist (Plasticulture) rakeshsharda@pau.edu	Co-PI
Mr. Jatinder Rai	Male	jatinderraipau@gmail.com	Senior Office Assistant
Navjeet Singh	Male	navjeet922@gmail.com	SRF
Ramandeep Kaur	Female	ramansidhu4001@gmail.com	SRF
Lovepreet Kaur	Female	lovepreetkaur11992@gmail.com	SRF
Sarveen Kaur	Female	sarveen-soil@pau.edu	SRF
Chandni	Female	chandnidhall72@gmail.com	SRF
Harpreet Kaur	Female	kpreeti.181@gmail.com	SRF
Sukhjinder Kaur	Female	sukhiratta@gmail.com	SRF
Kirandeep Kaur	Female	kiranchandi@pau.edu	SRF

Rajwant Kaur	Female	rajwantkaur23031997@gmail.com	SRF
Jugminder kaur	Female	jugminder3@gmail.com	SRF
Inderpal Singh	Male	inder.pau@gmail.com	SRF
Rajat Mishra	Male	rajatmishra826@gmail.com	SRF
Tanvi Sahni	Female	tanvi-cm@pau.edu	SRF

6.2. Details of visits of PIU-NAHEP officials at your AU along with photographs

Dr. R. C. Agarwal, DDG(Edn) & ND (NAHEP) and Dr. Anuradha Agrawal, NC (CAAST and Comp2A, NAHEP) vistied PAU, Ludhiana

Annexures

Annexure I

Key activities carried out under the project during the entire period

1.1 Interventions carried out by AU which helped to improved research effectiveness

Post Graduate Course on Natural Resources Management- Annexure Ia

These courses approved by Academic Council, PAU, Ludhiana are offered to the MSc, MTech and PhD students of the line departments like Soil Science, Agronomy, Soil & Water Engineering and Farm Machinery & Power Engineering.

NRM 501 Recent Techniques in Crop Residue Management vis-a-vis Soil Quality 2+1
Sem. II

Soil quality and its components. Indicators of soil quality. Soil organic carbon – Fractions and relations with soil quality. Factors affecting OC content accumulation in soils. Decomposition dynamics of different crop residues in soils. Role of differential tillage intensity on soil organic carbon. Impact of burning on soil quality. Crop biomass resource assessment techniques, supply chains. In-situ and ex-situ uses of crop residues in agricultural production system. In-situ management techniques crop residues. Machinery for crop residue management – classification, efficiency, standards and power requirements; advanced prototypes of crop residue management machinery. Ex-situ management techniques of crop residues – baling, mulching, densification, use as soil amendment, cushioning material for animals, composting and processing for animal feed.

Practical: Determination of soil organic fractions and carbon management index. Estimation of green house gas emission in agriculture. Estimation of soil physical fertility parameters. Estimation of soil biological fertility parameters. Familiarization with different straw management techniques: machinery for mulching and incorporation of straw for in-situ management and machinery for collection, loading and transport for bruised/loose straw. Straw baler, densification and making of bales in the field. Wheat straw collection machine and studies on its management in the field. Studies on advanced prototypes of machines for straw management. Practicals on usage of straw residues as energy material, soil amendment, cushioning material for animals, composting and processing for animal feed

NRM 502 Integrated Management of Water Resources 2+1
Sem. II

Status of hydrological cycle under changing climatic scenarios in urban and rural areas. Temporal trends of surface and ground water resources at global, national and regional levels. Inter-annual variations in rainfall patterns in different agroclimatic regions of the country including rain amount, intensity and distribution. Water budgeting at national and regional levels vis-à-vis agriculture. Concept of integrated water management. Rain water harvesting in urban and rural areas; utilization techniques of harvested rain water for ground water recharge and for storage. Agricultural water management – standardization of techniques for improved water efficiency; Computation of water requirements of major cropping systems with improved water conservation practices. Improved and precision techniques of irrigation in different crops. Waste water recycling – concept of STPs; utilization of treated waste waters in agriculture. Advanced techniques of micro-irrigation and fertigation under open and protected cultivation systems; standardization of hydroponics and aeroponics techniques.

Practical :Analysis of variability in amount and distribution of rainfall in view of climatic variations.. Spatio-temporal trend analysis of rainfall in an area or a watershed. Planning and cost estimation of rainwater harvesting for urban areas and watershed. Spatio-temporal trend analysis of groundwater levels in an area. Water balance of a rice -wheat cropping system. Determination of water requirement of different cropping systems. Visit and design of sewage treatment plant. Design of aero-ponics and hydroponics system. Preparation of fertigation solution from fertilizers for utilization in micro irrigation, hydroponics and aeroponics Design of micro irrigation system for farmer's field.

NRM 503 Natural Resources Management under Climatic Variability 2+0
Sem. I

Trends of climate change at global, country and regional level; climate change vs climate variability in the region. Anthropogenic activities leading to climate change and for climate variability. Changes in sources and sinks of carbon during the recent decades. Global warming – extent, reasons, impacts; global warming potential of major greenhouse gases (GHGs). Concept of carbon sequestration and its potential under different scenarios. Natural resources – uses, extent of depletion/degradation under climate change and/or climate variability. Adaption and mitigation strategies for managing water, air, soil/land, forests, oceans with respect to recent changes in climatic conditions. Population – its' role in depletion of natural resources, trends in population in different regions of the world.

NRM 504 Environmental Pollution and Management
2+0

Environment – components, types, issues; impacts on different social, cultural and economic effects. Environment in relation to agriculture. Soil pollution – extent, causes and impact on human-plant-animal continuum; Management strategies including phytoremediation. Salinity pollution. Air pollution – extent, causes and impacts on plant, human and animal life; urbanization and air pollution; Role of industries in air pollution. Water pollution – extent, causes and impact on food chain and human health; urban and industrial effluents and water pollution; Water pollution in village ponds; management options including bio-drainage.

Farm Machinery were improved i.e. paddy transplanter, smart seeder, baler - **Annexure Ib**

Annexure 1b

AUTONOMOUS REMOTELY CONTROLLED SYSTEM FOR 2-WHEEL PADDY TRANSPLANTER

Introduction

Manual transplantation of paddy is a labor-intensive operation that requires 200–300 man-h ha^{-1} and consumes approximately 72–89% of the total human energy of the operation. Farm workers have to frequently change their posture and adopt bending and sitting postures during transplantation, resulting in high heart and energy expenditure rates and going through neck-, shoulder-, back- and/or thigh pain. In addition, during the peak transplanting season, the scarcity of labor and resultant higher wages increases cultivation costs, delay transplantation, and reduce profitability. To reduce the human drudgery in manual transplanting, various types of manual and self-propelled paddy transplanters have been developed, such as the single-wheel riding paddy transplanter, four-wheel riding paddy transplanter, and two-wheel walk-behind paddy transplanter. In the Punjab state of India, it was estimated that out of the total mechanical transplanted area of about 25,025 ha, about 66% of the area was covered by walk-behind paddy transplanters. The areas covered by four- and single-wheel riding transplanters were 32.7 and 1.20%, respectively. Among the various available mechanical transplanters, walk-behind transplanters require more human involvement because the operator has to walk approximately 14–22 km in a day in puddled field conditions in a hot humid environment (38–44^{o} C, 70–80% RH) in summer. Moreover, an operator has to walk within a 30-cm row width, which causes chaffing between the thighs of the operator. In addition, psychological fatigue, workload and physiological stress owing to noise and mechanical vibrations can increase the risk of occupational health hazards and injuries.

Justification

In view of the scarcity of labor and other factors, interest in research, development, and adoption of automated/autonomous agricultural machines has been increasing. Various types of autonomous solutions for four-wheel riding paddy transplanters have been developed worldwide. However, no commercial autonomous remote system is available for two-wheel walk-behind paddy transplanters, except for a few ongoing studies. Still, there are significant issues regarding autonomous paddy transplanting systems that need to be addressed, such as straight path navigation systems, control during U-turns after completing a row, and refilling of paddy seedlings. Therefore, to reduce the physical and psychological workload of operator, a remotely controlled system for existing walk-behind type paddy transplanters has been designed and developed.

Outcome from the study

The outcome of the study will enable an operator to control the transplanter while sitting in a safe and comfortable location outside the field. Moreover, an operator could concurrently manage two or more paddy transplanters to improve working efficiency and alleviate the effect of labor shortages during the peak season. The economic and social impact of this advanced innovation catches the attention of young and educated farmers as an appealing endeavor. In addition, with modifications and future development, this technology could be implemented to operate other self-propelled farm machinery to reduce human fatigue and drudgery with enhanced field efficiency.

Methodology

Design of Electronic control unit

During 2019-20, to develop the remotely controlled system of existing walk behind type paddy transplanter, the electronic control system (ECS) was designed to control the hand levers through sensors, electronic control units, actuators, and motors. A separate hand-held remote kit was also invented to control the forward, reverse, left and right movement, brakes along with the start and stop of transplanting mechanism. A wireless receiver was used to transfer the electric signals from the hand-held remote kit.

Design of actuating frame mechanism

During 2020-21, An existing Kubota make four-row, two-wheel, walk-behind paddy transplanter (NSP-4W, MZ175-B-1) was selected and purchased for this study because of its superior adoption rate among other available makes/models of walk-behind transplanters. This transplanter has a single-cylinder, air-cooled, four-cycle, OHV petrol engine. The transplanter has two wheels, and the weight of the transplanting machine stands on the lugged wheel and floats during transplanting. The machine has four rows with a fixed inter-row spacing of 300 mm and adjustable hill/plant spacing. Its control levers are hand-operated push/pull-type levers.

Before developing the actuating frame mechanism for autonomous walk-behind paddy transplanters, the various hand-control parameters of height from the ground, displacement length, actuating forces, and torque applied to the control levers were measured. A 3-D design of actuating hand-control levers through electric linear actuators was developed using Solid Works 3D CAD design software (Vr. 2020). Initially, various parts including a control panel consisting of hand-control levers and mountings holders/frames of electric linear actuators for control levers were developed, and these components were assembled to obtain the final 3-D model of the system. The developed frame was mounted beneath the control panel of the transplanter, and three linear actuators were installed and connected to the respective control levers with hinges and couplings.

Funding: The main base machine (Kubota make) was procured under the National Agricultural Higher Education Project (NAHEP). The procurement of some electronic items and frame development work was procured under RKVY

Industry Collaboration: Execution of the fabrication and development work was done in collaboration with M/s T&D Electronics, Ludhiana.

Patent filing: The concept of the design was filed for patent Ref. No./Application No. 202111019252 on 27.04.2021.

Field Evaluation

During 2021, the performance evaluation and optimization of machine-field parameters of the developed remote control system was done with three levels of soil puddling settlement period (4, 26 and 48 h), three forward speeds (1.40, 1.85 and 2.30 km h^{-1}) in two types of soils (sandy loam and loam). The results revealed that the response factors, i.e the effective field capacity and field efficiency was affected by forwarding speed, soil type and soil puddling settlement period, but no significant effect was observed at the interaction level. The optimal value of soil puddling settlement period was 26 h at a forward speed of 2.0 km h^{-1} for sandy loam type soil, whereas for loamy soil, it was 30 h at 1.82 km h^{-1}. A total saving of up to 18.2 % labor requirement was observed as required in the existing walk-behind type paddy transplanter. The increase in effective field capacity was observed up to 20%, resulting the net benefit per unit area and per year has been increased by 6.6% and 15.9% respectively. The overall results of the field evaluation showed that the remote-controlled system for two-wheel paddy transplanter would be feasible at optimized field and machine parameters.

Patent filing: The final patent of the design was filed for patent Ref. No./Application No. 202111019252 on dated 19.04.2022.

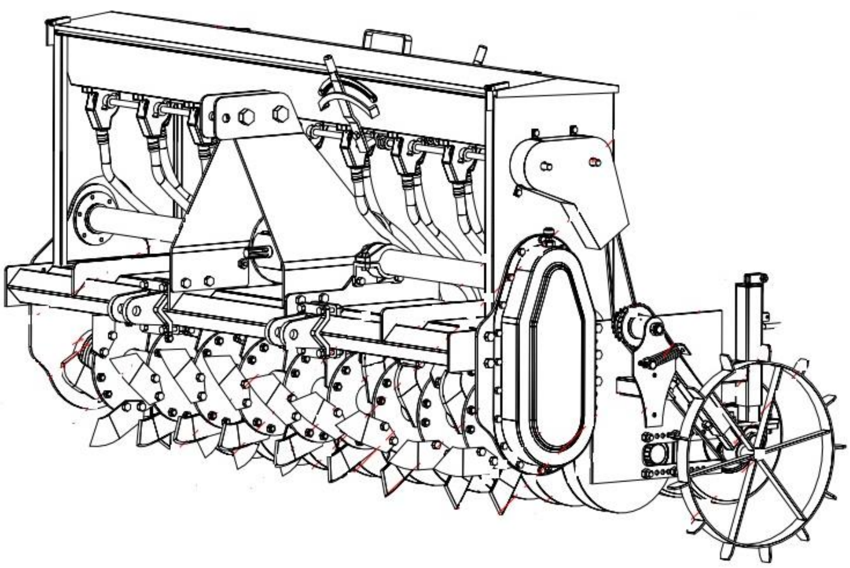
Success Story II

PAU SMART SEEDER

The first prototype of PAU Smart seeder was developed at the Department of Farm Machinery and Power Engineering, PAU, Ludhiana during 2018-19. Further, PAU Smart Seeder (PSS) was upgraded, fine-tuned and evaluated for a four-wheel tractor that can sow wheat with optimum crop establishment in combine harvested rice fields during 2019-20 and 2020-21 under the NAHEP CAAST-SNRM project. The PSS was evaluated for its performance under varying straw load, forward speed, and rotor speed in terms of fuel consumption, field capacity, seed emergence, and grain yield. The crop establishment and wheat yield of PSS was also compared with the existing straw management machines Happy Seeder (HS) and Super Seeder (SS) under heavy paddy residue conditions (>8 t ha^{-1}).

The PSS combines the positive effects of both the processes of incorporation and surface retention of residues in one machine; therefore, the fuel consumption of PSS was observed to be intermediate between that of HS and SS. HS is a zero tillage machine, SS is a complete tillage machine while PSS tills around 32.5 % (75 mm wide) of machine width. The PSS manages the paddy stubbles partly by surface mulch (in between seed rows) and by tillage and incorporation in seed rows. The tillage in seed rows increases the soil seed contact and seed row visibility (after sowing operation) which provides better satisfaction and confidence to the farmers compared to sowing by HS. Moreover, residue retention in between seed rows provides benefits of weed suppression, moisture conservation, and slow decomposition of paddy residues as observed in case of HS.

The PSS incorporates only a small part of the straw in the soil and retains the majority of straw as surface mulch due to this the chances of seeds dropping on straw are lesser. On the other hand, the SS does provide a clean look of the field due to which the farmers are attracted to the machine but it pushes the residue into the soil without size reduction (Chopping) and covers residue by a thin layer of soil. Thus, wheat germination in case of SS is patchy and lower due to lesser soil seed contact. The germination in the case of PSS is better than SS as the seeds are placed in well-tilled soil strip having a lesser amount of paddy residues as most of the residues are retained as surface mulch. Wheat emergence was higher by 15.6 and 25.7% on the PSS plots compared with HS and SS, respectively. The comparative crop establishment video of wheat in paddy residues after 70 days of sowing using HS, SS, and PSS into 8.1 t ha^{-1} paddy straw (*PR-121*) is available online at https://youtu.be/kd-Zu5jvbRg. Average wheat grain yield in PSS-plots was significantly higher by 12.7% and 18.9 % than SS and HS, respectively in one experiment, while the grain yield was similar for both PSS and HS in other experiments. In conclusion, PSS showed better promise for in-situ management of rice straw as it eliminates most of the operational problems encountered by the exiting seeders (HS and SS).



Isometric view of PAU Smart Seeder (front)


KAMBOJ
SMART SEEDER

Technology Marketing and IPR Cell
Directorate of Research
Punjab Agricultural University
Ludhiana

Commercialization of PAU SMART SEEDER through Transfer of Technology by PAU

Sr. No.	Date of MoU	Technology	Name of Organization
1.	20.02.2022	PAU Smart Seeder	M/s.GSA Industries, Patiala
2.	20.02.2022	PAU Smart Seeder	M/s.Kamboj Mechanical Works, Ajnala, Amritsar
3.	20.02.2022	PAU Smart Seeder	M/s. National Agro Industries, Ludhiana
4.	20.02.2022	PAU Smart Seeder	M/s. Dasmesh Mechanical Works, Sangrur
5.	20.02.2022	PAU Smart Seeder	M/s. Guru Nanak Agri Works, Phillaur
6.	24.03.2022	PAU Smart Seeder	M/s Punjab engineering works (regd.) Talwandi bhai-142050, district -Ferozepur, Punjab, India
7.	24.03.2022	PAU Smart Seeder	M/s Dhanjal Agriculture Industries (Regd.) Ludhiana Road, Gondwal-Raikot 1411109 (Ludhiana)
8.	25.04.2022	PAU Smart Seeder	M/s. Hoshiarpur Steel, Labh Nagar, Hoshiarpur, Punjab
9.	15.07.2022	PAU Smart Seeder	M/s Bir Singh and Sons, Chandigarh Road Samarala 141114

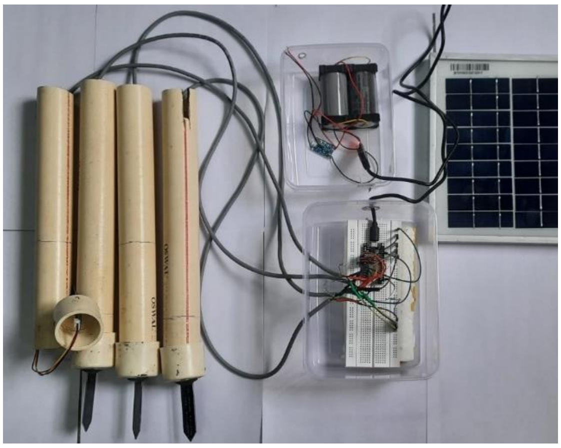
Success Story III

SOIL MOISTURE SENSOR SYSTEM

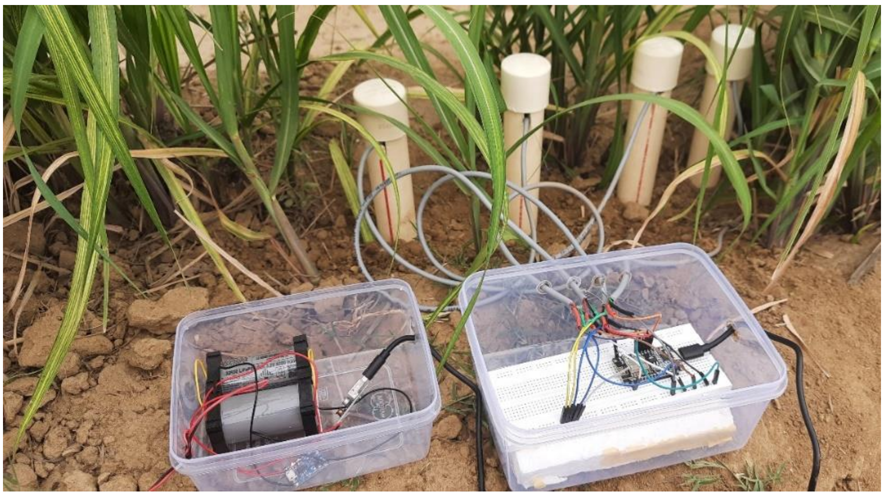
Real-time monitoring of soil moisture can provide useful information for optimizing the amount and timing of irrigation. Among the range of different soil water sensing technologies, capacitance-type soil moisture sensors are the most popular because of their cost, reasonable robustness and precision, low power consumption, and low maintenance requirements. These sensors are not popular among farmers as these sensors give good accuracy in laboratory conditions; in field conditions they show large sensor-to-sensor variability. One explanation for this variability is that they only perceive a small volume of soil (in the order of 1 dm3), which makes them very sensitive to local variations, for example, gravel content, bulk density, soil salinity, the existence of macropores and shrinkage cracks, the proximity of plant roots, and small-scale surface features. The objective of this study is to measure capacitive sensors measurements of SWC in laboratory conditions and to develop a dynamic program to reduce variability among different sensors. The soil moisture sensors are more sensitive to either to recent balance of last irrigation cycle or aggregate balance of several cycles. Therefore, one constant value of sensor voltage cannot suggest the irrigation scheduling. Therefore, a dynamic program is required to process sensor voltage by comparing it with the voltage of previous irrigation cycle. The developed sensor module performance was observed to be at par with the commercial soil moisture sensing module to monitor soil moisture in the field.

A low cost sensor module was developed using the available sensors, microcontroller, buck boost converter, solar panel, charging and discharging module and battery. The soil moisture module consists of capacitive moisture sensor which uses capacitive sensing to detect soil moisture. Four capacitive sensors were used with one microcontroller to make the module robust to soil moisture profile compaction and moisture variability. ESP 8266 micro controller was programmed in Ardunio IDE in such a way that it records 60 values of voltage across all the capacitance sensor and sends its average value to the cloud server. The capacitance sensor was enclosed in 40 mm PVC pipe having endcaps on both sides. The endcap on one side was slotted to place the soil moisture probe in such a way that the sensing part of probe come out of endcap and circuit board remains enclosed in the PVC pipe. The epoxy resin was used to fix the sensor in endcap to make the module water resistant. Silicone gel packs were placed inside the PVC pipe to avoid the effect of humidity change on the soil moisture senor output. This ruggedness enabled the low cost sensors to be used for monitoring soil moisture content at 20 cm or more depth. The low cost sensor system conceptualized, developed and evaluated under NAHEP CAAST-SNRM project that was compared with the commercially available sensors and found to be at par in moisture prediction. Therefore, the low cost sensor system can be used at farmers field for precise application of water.

Training on Soil Moisture Sensor System Development	Feb, 2020
Prototype Development of Sensor System	Oct-Dec, 2020
Testing of Protype in Lab	Jan, 2021
Testing in Field	Feb, 2021
Installation in field for moisture sensing	Mar, 2021
Filed Data Monitoring	Mar to Dec, 2021



Developed Soil Moisture System



Sesnor System Insatlled in the field

NAHEP CAAST-SNRM Project at PAU

Success Story IV

DEVELOPMENT OF SENSOR BASED INTEGRATED SYSTEM FOR MEASURING SOIL COMPACTION AND ELECTRICAL CONDUCTIVITY OF SOIL

The tractor-mounted and hydraulically operated real-time sensor-based integrated system for measuring soil compaction and electrical conductivity of soil was successfully developed and evaluated in the field. The design parameters of the developed soil sensor were similar to ASAE Standard S313.3 with the incorporation of soil electrical conductivity measuring sensors at the tip of the cone of the probe. The major components of the developed cone penetrometer were a frame, hydraulic cylinder, probe, ultrasonic depth sensor, global position system (GPS), control panel, and data acquisition system (Fig. 1). The Finite Element Analysis (FEA) of the critical parts as well as the whole assembly with different types of materials was done by using ANSYs software (Fig. 2). The Structural steel was selected for the construction of the frame of the soil sensor due to easy availability and cost efficiency. The En8 was selected for the fabrication of the probe of the assembly and low carbon-based steel (EN 8 BS970 080M40) material was selected for the hydraulic cylinder.

The developed soil sensor was evaluated in two different types of soil at two different locations after the harvesting of the wheat crop, where the paddy crop was the previous crop in rice-wheat rotation, and paddy residue was managed as per the treatments for electrical conductivity (Fig. 3). The three treatments for both locations were treatment T1 (rice residue retained on the soil), treatment T2 (rice residue removed manually), and treatment T3 (rice residue incorporated). The developed soil sensor showed sensing mean accuracy of 95.38 and 95.06% for soil compaction measurement in comparison with manual cone-penetrometer and, 73.42 and 74.45% for soil electrical conductivity measurement in comparison with standard laboratory method in sandy loam soil (S1) and loamy soil (S2), respectively. The coefficient of correlation between the developed soil sensor and hand cone penetrometer was R^2= 0.88 and R^2= 0.83 for sandy loam soil (S1) and loamy soil (S2) respectively. The coefficient of correlation between the developed soil sensor and laboratory method for electrical conductivity measurement was R^2= 0.93 and R^2= 0.89 for sandy loam soil (S1) and loamy soil (S2) respectively. The overall results of the machine concluded that it was feasible to adopt the developed soil sensor to establish a reliable, faster, and cost-effective soil compaction monitoring system, simultaneously with EC measurements.

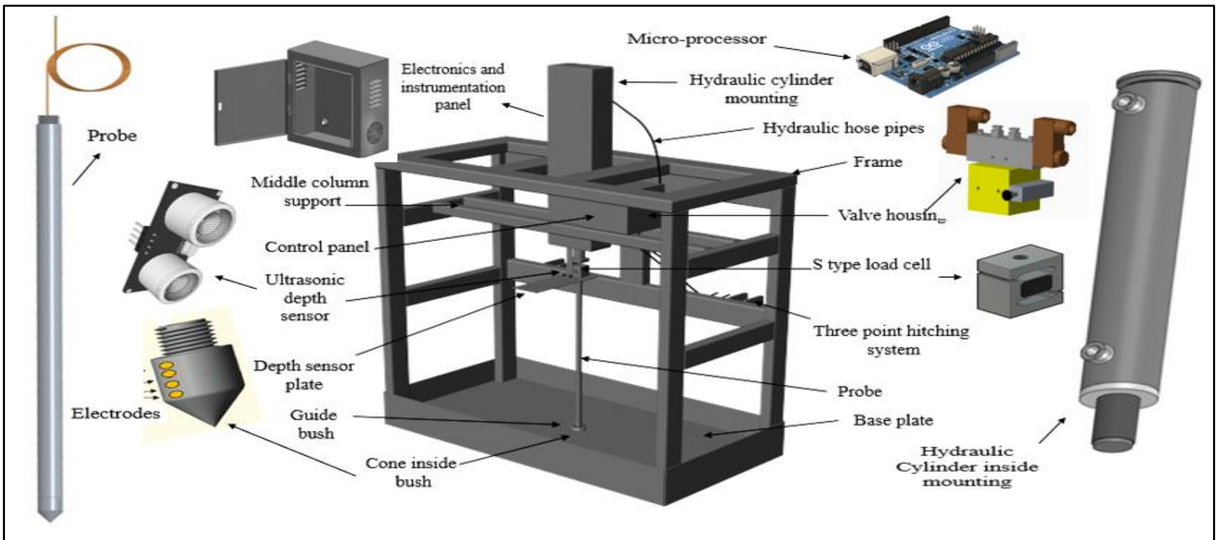


Fig. 1: Major assembly components of the developed dual soil sensor system.

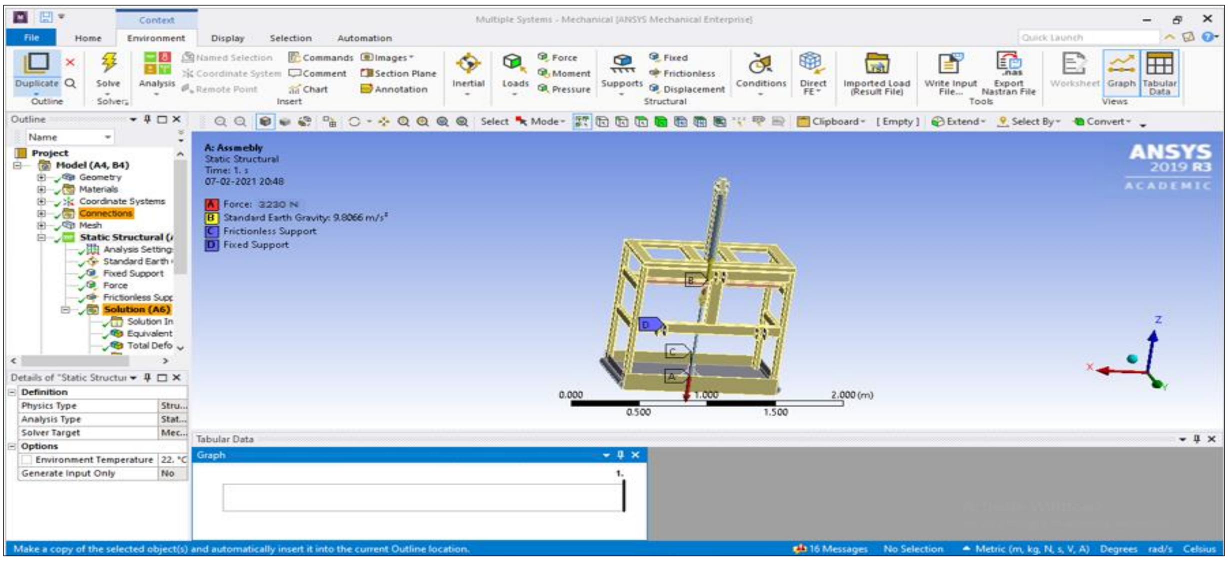
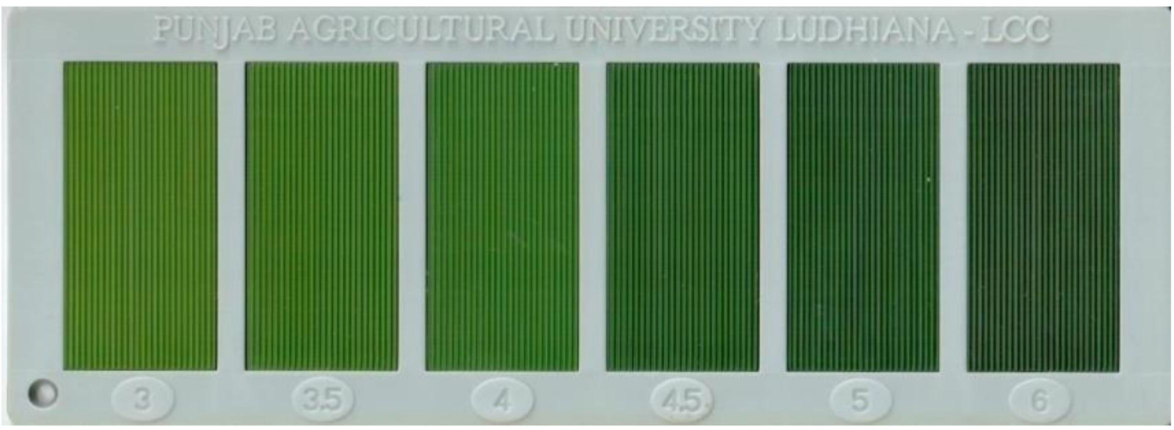


Fig. 2: Stress analysis of the assembly components in a single screen view in ANSYS R3 software.

Fig. 3: Validation of the developed dual soil sensor system in the field under different treatments.

Success Story V

SUCCESS STORY ON PAU UREA GUIDE MOBILE APP FOR ADOPTION OF PAU-LEAF COLOUR CHART FOR NEED BASED N MANAGEMENT IN FIELD CROPS



Farmers usually make fertilizer N topdressing decisions based on leaf colour. However, they don't understand the interpretation of colour, and generally go for excessive fertilizer N applications to keep their crop lush green in comparison to the neighbouring farmer's fields. Fertilizer N applications over and above the crop requirement do not generally increase grain yield. Conversely, increased succulence, over growth and dark green colour results in increased incidence of insect pests, and the crop sometimes becomes more prone to lodging. A large proportion of the applied N escapes from soil-plant systems to the atmosphere and underground water bodies causing environmental damage.

The Punjab Agricultural University (PAU), Ludhiana systematically conducted the study of spectral properties of major field crops (rice, wheat, maize and cotton) using optical sensors and chlorophyll meters and ultimately developed the PAU-Leaf Colour Chart (PAU-LCC) as a versatile and economical gadget for farmers. The PAU-LCC, that measures leaf colour variations of 5 SPAD (Soil Plant Analysis Development Meter) units and provides N recommendations in major field crops, is a breakthrough development in the application of nitrogen. The PAU-LCC technology is a farmers' friendly technology as farmers already use leaf colour as an index for deciding N topdressings although ignorant of the relevance of leaf colour thresholds.

The Department of Soil Science developed a success story on the adoption of PAU-Leaf Colour Chart at the village Bassian, Ludhiana which is quite inspiring. After slow response during 2017, almost all the farmers (about 150) of the village adopted PAU-LCC in rice during 2019-20 and thereafter. The use of PAU-LCC led to the production of an equivalent grain yield with an average saving of 50-80 kg N per hectare in rice and 50 kg N per hectare in wheat in comparison with the farmers' usual practice.

Assuming an average saving of only 30 kg nitrogen per hectare (although the average saving at the village of Bassian is much more), the adoption of PAU-LCC in all the fields of rice, wheat, maize and cotton in the Indian Punjab alone could annually save 7.5 billion INR (2.5 billion of farmers and 5 billion of the Government). The saving of expenditure on the reduced consumption of insecticides/pesticides would further improve farmers' income. Jagdev Singh, Head of the village Bassian told that all the farmers in his village saved at least one spray of insecticide/pesticide while adopting PAU-LCC technology and the maximum saving is reported up to three spays.

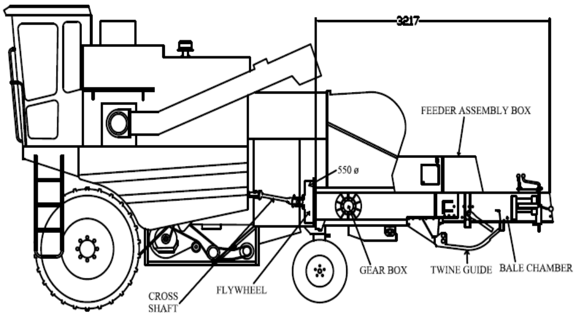
The recommendations derived using PAU-LCC based fertilizer N management in transplanted rice, direct seeded rice, basmati rice, wheat, maize and cotton are available in the PAU Package of Practices for *Rabi* and *Kharif* crops. A decision support system for need-based fertilizer N use in field crops was developed with support from CAAST SNRM Project in operation at PAU and is now also launched as 'PAU-Urea Guide App'. The App is available for free download for smart phone users both at Google Play store and Apple App store and can be used in English, Punjabi and Hindi languages. The adoption of the PAU-Urea Guide App based N management practices will substantially reduce the fertilizer N use in Indian agriculture, increase farmers' income, reduce insecticide and pesticide consumption while mitigating air and water pollution and saving exchequer of government from huge subsidy on N fertilizer.

Success Story VI

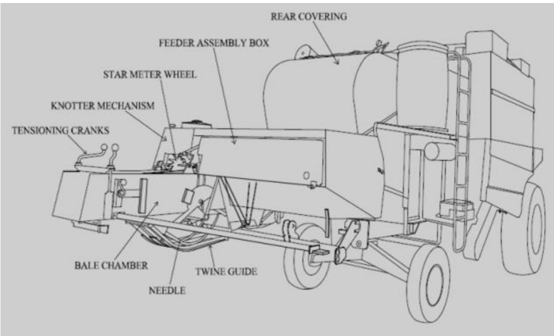
RECTANGULAR STRAW BALER

A baling attachment with the self-propelled combine harvester was designed and developed for baling of loose straw coming out from combine harvester which enables the harvesting and baling operation of rice straw to be done simultaneously. The baling attachment with self-propelled combine harvester consists of rectangular baler and rear cover attached to the chassis of the combine harvester, flat belt conveyor system for conveying the loose residue coming out from the straw walkers of the combine harvester to the feeder system of the baler for baling of loose residue. The baling attachment with the combine harvester had been tested during the paddy and wheat harvesting in the year 2020-21. The operational parameters were selected as forward speed as 2.0 km/h with the belt conveyor speed of 1.15, 1.40 and 1.50 m/s for better and smooth operation of combine harvester with baling attachment during wheat harvesting. Bruised wheat straw samples from baling attachment with self-propelled combine harvester, commercial wheat straw combine and *Harambha* thresher were collected and the quality of the bruised wheat straw samples (straw size, ash content, acid insoluble ash and dust concentration) were examined. The average percent ash content for baling attachment was 9.30 % whereas, for commercial straw combine (control) and *harambha* thresher, it was 13.80 % and 8.90 % respectively. The ash content in bruised wheat straw from baling attachment was 4.5 % lesser as compared to commercial wheat straw combine (control). The mean acid insoluble ash in bruised wheat straw from baling attachment was 5.38 % and it was 6.81 and 4.12 % in straw obtained from commercial straw combine (control) and *harambha* thresher, respectively. The acid insoluble ash was 1.43 % lesser in bruised wheat straw from baling attachment as compared to commercial wheat straw combine. As per recommendations of the Department of Animal Nutrition, GADVASU, the ash content and acid insoluble ash (AIA) in the wheat straw should not exceed 7-8 % and 4-5 %. It can be concluded that values of ash content and acid insoluble ash obtained from bruised straw from baling attachment and *harambha* thresher lies closely to the recommended values given by the Department of Animal Nutrition, GADVASU, Ludhiana

The baler attachment to combine harvester for harvesting paddy puts an additional load on the combine engine which reduces the field capacity of combine harvester significantly. Therefore, more research work is required to make the baler attachment onto combine harvester as commercially a viable option.



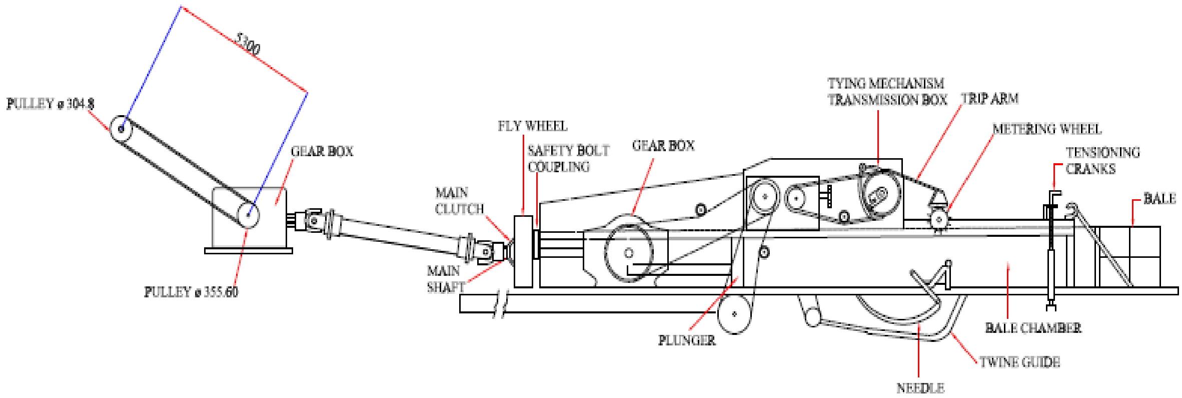
A side view of the developed baling attachment with self-propelled combine harvester



A rear view of baling attachment with self-propelled combine harvester

Bale ejected from the baling attachment with self-propelled combine harvester

A



schematic view of the power transmission of the baling attachment with the self-propelled combine harvester

Combine harvester with baling attachment during the wheat harvesting

Success Story VII

DEVELOPMENT OF UAV/DRONE BASED SPRAYING SYSTEM FOR INTENSIVELY CULTIVATED RICE-WHEAT SEQUENCE

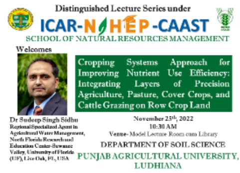
A study was planned to investigate different design and operations parameters of selected nozzles to reduce drift during spraying with drone. Nozzles with (extended range flat fan spray tip, standard flat fan spray tip and turbo flat fan spray tip) were tested at three levels of operating pressure (0.96, 1.38 and 1.63 kg cm-2) and height (2, 3 and 4 m) in simulated field conditions for determining effective swath width, deposition characteristics and drift potential. The optimum value of all three nozzles were found at operating pressure of 1.38 kg cm-2 and height of 3 m in simulated field conditions. Also, drift and penetration in the paddy and moong field was measured in with 3 levels of forward speed (2, 3 and 4 m s-1). One optimum combination of nozzle type (extended range flat fan spray tip), operating pressure (1.38 kg cm-2) and flying height (3 m) were selected from the previous experiment and kept constant while recording observations in the crops. It was found that at forward of 2 m s-1, spray coverage remained maximum for both crops. Spray coverage decreased from top to bottom position in the case of moong. Spray coverage was recorded highest value at upper side of top position in both crops and their values were 24.22% in paddy and 17.88% in moong. Horizontal drift remained the lowest at 3 m s-1 forward speed and vertical drift increased with the increase in forward speed of drone in both the selected crops.

For spraying, hexacopter drone fitted with standard/extended flat fan nozzle or anti-drift/air induction nozzles can be used for aerial spraying system to be operated at pressure 1.38 kg cm-2. along with forward speed of drone 2.0-3.0 m/s and at the height of 2-3 m from the crop. 4-Band MS camera is also being used for variable rate nutrient application and other studies of crop monitoring

Drone and its Drift Testing Facility

Distinguished lecture series - 07 lectures- Annexure Ic

Title of Event	No. of Participants	Host Department	Event Duration (days)	Remarks
Role of Soil Science Research in Natural Resource Conversation by Dr S M Virmani, Soil Scientist & Climatologist of International Fame & presently Honorary Adjunct Professor, PAU, Ludhiana	50	Department of Soil Science, PAU, Ludhiana	25 March, 2019	
Environmental pollution & Climate Change: Challenges and possible solutions by Dr M.S. Aulakh, Founder Vice-Chancellor, Banda University of Agriculture & technology, Banda (U.P.)	45	Department of Soil Science, PAU, Ludhiana	27 March, 2019	
On-farm management of crop residues for improving soil health and environment quality by Dr. Yadvinder Singh, FNA and INSA Honorary Scientist, PAU, Ludhiana	46	Department of Soil Science, PAU, Ludhiana	28 March, 2019	
Matlab based Modeling, Simulation and Control of Robotic Manipulators by Dr Ashish Singla, Associate Professor, Department of Mechanical Engineering, Thapar Institute of Engineering and Technology (deemed to be University), Patiala	50	Department of Soil & Water Engineering, PAU, Ludhiana	29 March, 2019	

Cropping Systems Approach for Improving Nutrient Use Efficiency: Integrating Layers of Precision Ag., Pasture, Cover Crops, and Cattle Grazing on Row Crop Land by Dr. Sudeep Singh Sidhu, Regional Specialized Agent in Agricultural Water Management, North Florida Research and Education Center-Suwanee Valley, University of Florida (UF), Live Oak, FL	55	Department of Soil Science, PAU, Ludhiana	November 25th 2022	
Nutrient Management and Water Quality by Dr. Lakesh Sharma, Asstt Professor, Soil Fertility and Sustainable Agriculture, Soil and Water Sciences Department *University of Florida, Gainesville, FL, USA*	70	Department of Soil Science, PAU, Ludhiana	November 30th 2022	
Lecture on Digital Soil Mapping for Sustainable Soil Management by Dr. Priyabrata Santra	50	Department of Soil Science, PAU, Ludhiana	June 29th, 2022	

Annexure II

S. N.	Research Papers/Books/Book chapters/Training manuals/monographs	NAAS rating/ Impact factor
1.	Aulakh CS., Sharma S., Thakur M. and Kaur P. (2022). A review of the influences of organic farming on soil quality, crop productivity and produce quality. *Journal of Plant Nutrition.* DOI: 10.1080 /01904167.2022.2027976.	8.28
2.	Bijay-Singh, Varinderpal-Singh and Ali M. (2020). Site-specific fertilizer nitrogen management in cereals in South Asia. In: Lichtfouse E (eds.) *Sustainable Agriculture Reviews,* 39: 137-178.	3.99 (Impact Factor)
3.	Brar, AS., Buttar, GS., Singh M., Singh S. and Vashisht KK. (2021). Improving bio-physical and economic water productivity of menthol mint (*Mentha arvensis* L.) through drip fertigation. *Irrigation Science,* 1-12. https://doi.org/10.1007/s00271-021-00722-6.	9.52
4.	D. Dey, D. and Mavi, M.S. (2022) Co-application of biochar with non-pyrolyzed organic material accelerates carbon accrual and nutrient availability in soil. *Environmental Technology & Innovation.* 25:102128.	13.76
5.	Dhaliwal SS., Sharma S., Shukla AK., Sharma V., Bhullar MS., Dhaliwal TK., Alorabi M., Alotaibi SS., Gaber A. and Hossain A. (2021). Removal of biomass and nutrients by weeds and direct-seeded rice under conservation agriculture in light-textured soils of North-Western India. *Plants,* 10: 2431. https:// doi.org/10.3390 /plants10112431.	4.65 (Impact Factor)
6.	Dhawan G., Dheri GS. and Gill AAS. (2020). Long-term use of balanced fertilization decreases nitrogen losses in a maize-wheat system on *Inceptisol* of north India. *Archives of Agronomy and Soil Science,* 1-18. DOI:10.1080/03650340.2020.1836347.	8.24
7.	Dhawan G., Dheri GS. and Gill A.A.S., 2021. Nitrogen budgeting of rice-wheat cropping system under long-term nutrient management in an Inceptisol of north India. *European Journal of Agronomy, 130:*126376.	11.72
8.	Dheri GS, Lal R and Moonilal Nall (2022). Soil carbon stocks and water stable aggregates under annual and perennial biofuel crops in central Ohio. *Agriculture, Ecosystem and Environment, 324:* 107715 https://doi.org/10.1016/j.agee.2021.107715	6.57 (Impact Factor)
9.	Dheri GS. and Nazir G. (2021). A Review on Carbon pools and Sequestration as influenced by Long-Term Management Practices in a Rice-Wheat Cropping System. *Carbon Management.* https://doi.org/10.1080/17583004.2021.1976674	9.52
10.	Gupta RK., Hussain A., Sooch SS., Kang J.S., Sharma S. and Dheri G.S. (2020). Rice straw biochar improves soil fertility, growth, and yield of rice–wheat system on a sandy loam soil. *Experimental Agriculture,* 56 (1): 118-131.	8.23

11.	Jagdeep-Singh and Varinderpal-Singh. (2021). Prediction of spring maize yields using leaf color chart, chlorophyll meter, and GreenSeeker optical sensor. *Experimental Agriculture,* 57: 45-56.	8.23
12.	Jagdeep-Singh., Varinderpal-Singh. and Satwinderjit-Kaur. (2020). Precision nitrogen management improves grain yield, nitrogen use efficiency and reduces nitrous oxide emission from soil in spring maize. *Journal of Plant Nutrition,* 43: 2311-2321.	8.28
13.	Jha P., Lakaria BL., Vishwakarma AK., Wanjari RH., Mohanty M, Sinha NK., Somasundaram J., Dheri GS., Dwivedi AK., Sharma RP. and Singh M. (2021). Modeling the organic carbon dynamics in long-term fertilizer experiments of India using the Rothamsted carbon model. *Ecological Modelling*, *450:* 109562.	9.51
14.	Jyolsna, T., Vashisht, B. B., Yadav, M., Kaur, R., and Jalota, S. K. (2024). Field and simulation studies on yield, water and nitrogen dynamics and use efficiency in rice-wheat crops in sequence. *Field Crops Research*, 311, 109366.	11.80
15.	Kaur N., Vashist KK. and Brar AS**.** (2021). Energy and productivity analysis of maize-based crop sequences compared to rice-wheat system under different moisture regimes. *Energy,* 216: 119286, 1-11. https://doi.org/10.1016/j.energy.2020.119286.	14.86
16.	Kaur R., Kaur S., Deol JS., Sharma R., Kaur T., Brar AS. and Choudhary OP. (2021). Soil Properties and weed dynamics in wheat as affected by rice residue management in the rice–Wheat cropping system in South Asia. *Plants,* 10: 953. https://doi.org/10.3390/ plants10050953.	4.65 (Impact Factor)
17.	Kaur S., Singh R., Vashisht BB., Gill KK. and Aggarwal R. (2020). Modelling the response of paddy water balance on groundwater level fluctuations in Central Punjab. *Journal of Hydroinformatics*. doi.org/10.2166/hydro.2020.058.	9.06
18.	Kaur, T., Sharma, P. K., Brar, A. S., Vashisht, B. B., and Choudhary, A. K. (2024). Optimizing crop water productivity and delineating root architecture and water balance in cotton–wheat cropping system through sub-surface drip irrigation and foliar fertilization strategy in an alluvial soil. *Field Crops Research*, 309, 109337.	11.80
19.	Kumar, DS., Sharma R. and Brar AS. (2021). Optimising drip irrigation and fertigation schedules for higher crop and water productivity of oilseed rape (*Brassica napus* L.). *Irrigation Science,* 1-14. https://doi.org/10.1007/s00271-020-00714-y.	9.52
20.	Lohan SK., Narang MK., Singh M., Singh D., Sidhu HS., Singh S., Dixit AK. and Karkee M. (2021). Design and development of remote-control system for two-wheel paddy transplanter. *Journal of Field Robotics*. 1-11. https://doi.org/10.1002/rob.22045.	6.38 (Impact Factor)

21.	Mavi MS., Bhullar RS. and Choudhary OP. (2020). Differential ability of pyrolysed biomass derived from diverse feedstocks in alleviating salinity stress. *Biomass Conversion and Biorefinery*. doi.org/10.1007/s13399-020-01087-0 .	10.05
22.	Moring A., Hooda S., Raghuram N., Adhya TK., Ahmad A., Bandyopadhyay SK., Barsby T., Beig G., Bentley AR., Bhatia A., Dragosits U., Drewer J., Foulkes J., Ghude SD., Gupta R., Jain N., Kumar D., Kumar RM., Ladha JK., Mandal PK., Neeraja CN., Pandey R., Pathak H., Pawar P., Pellny TK., Poole P., Price A., Rao DLN., Reay DS., Singh NK., Sinha SK., Srivastava RK., Shewry P., Smith J., Steadman CE., Subrahmanyam D., Surekha K., Venkatesh K., Varinderpal-Singh., Uwizeye A., Vieno M. and Sutton MA. (2021). Nitrogen challenges and opportunities for agricultural and environmental science in India. *Frontiers in Sustainable Food Systems,* 5: 505347.	11.01
23.	Mukherjee, S., Mavi, M.S. and Singh, J. (2020). Differential response of biochar derived from rice-residue waste on phosphorus availability in soils with dissimilar pH. *International Journal of Environmental Science & Technology,* **17**: 3065-3074.	3.52 (Impact Factor)
24.	Nima D., Aulakh CS., Sharma S. and Kukal SS. (2020). Assessing soil quality under long-term organic vis-a-vis chemical farming after twelve years in north-western India. *Journal of Plant Nutrition*. doi.org/10.1080/0 1904167.2020. 1862195.	8.28
25.	Nitika Sandhu., Amandeep Kaur., Mehak Sethi., Satinder Kaur., Varinderpal-Singh., Achla Sharma., Alison R Bentley., Tina Barsby. and Parveen Chhuneja. (2021). Genetic dissection uncovers genome-wide marker-trait associations for plant growth, yield, and yield-related traits under varying nitrogen levels in nested synthetic wheat introgression libraries. *Frontiers in Plant Science*. doi: 10.3389/fpls.2021.738710	12.63
26.	Panwar P., Chauhan S., Das DK., Kaushal R., Arora G. and Chaturvedi S. (2021). Soil organic carbon dynamics in *Populus deltoides* plantations using RothC-model in the Indo-Gangetic region of India. *Current Science,* 121(12): 1623-1627.	7.17
27.	Ramteke PR., Vashisht BB., Sharma S. and Jalota SK. (2021). Assessing and ranking influence of rates of Rice (Oryza sativa L.) straw incorporation and N fertilizers on soil physicochemical properties and Wheat (Triticum aestivum L.) yield in Rice-Wheat system. *Journal of Soil Science and Plant Nutrition,* 22: 515-526.	9.61
28.	Sharma S., Singh P. and Sodhi GPS. (2020). Soil organic carbon and biological indicators of uncultivated vis-à-vis intensively cultivated soils under rice–wheat and cotton–wheat cropping systems in South-Western Punjab. *Carbon Management,* DOI: 10.1080/17583004.2020.1840891.	9.52
29.	Sharma S., Singh P., Chauhan S. and Choudhary OP. (2022). Landscape position and slope aspects impacts on soil organic carbon pool and biological indicators of a fragile ecosystem in high-altitude cold arid region. *Journal of*	9.61

	Soil Science and Plant Nutrition. https://doi.org/10.1007 /s42729-022-00831-x	
30.	Sharma S., Singh P., Sukhjinder Kaur. and Yadvinder-Singh. (2022). Fertilizer-N application and rice straw incorporation impacts on crop yields, potassium use efficiency and potassium fractions in a rice–wheat cropping system. *Communications in Soil Science and Plant Analysis*. https://doi.org/ 10.1080 /00103624 .2022.2028816	7.58
31.	Sharma S., Vashisht BB., Singh P. and Yadvinder-Singh. (2022). Changes in soil aggregate-associated carbon, enzymatic activity and biological pools under conservation agriculture-based practice in rice-wheat system. *Biomass Conversion and Biorefinery*. https://doi.org/ 10.1007/ s13399-021-02144-y	10.05
32.	Sharma, S. and Dhaliwal, SS. (2021). Conservation agriculture-based practices enhanced micronutrients transformation in earthworm cast soil under rice-wheat cropping system. *Ecological Engineering,* 163 :106195.	10.38
33.	Sharma S. and Dhaliwal SS. (2020). Rice residue incorporation and nitrogen application: effects on yield and micronutrient transformations under rice–wheat cropping system. *Journal of Plant Nutrition*, 48:1-15.	8.28
34.	Sharma S., Singh P., Choudhary OP. and Neemisha. (2021). Nitrogen and rice straw incorporation impact nitrogen use efficiency, soil nitrogen pools and enzyme activity in rice-wheat system in north-western India. *Field Crops Research,* 266:108131.	12.15
35.	Singh, G., Mavi, M.S., Choudhary, O.P., Kaur, M., Singh, B.P. (2022) Interaction of pyrolysed and un-pyrolysed organic materials enhances carbon accumulation in soil irrigated with water of variable electrical conductivity. *Soil & Tillage Research*. 215, 105193.	13.37
36.	Singh, G., Mavi, M.S., Choudhary, O.P., Kaur, M., Singh, B.P. (2021) Rice straw biochar application to soil irrigated with saline water in a cotton-wheat system improves crop performance and soil functionality in north-west India. *Journal of Environmental Management*, 295: 113277	14.91
37.	Singh K., Brar AS. and Mishra SK. (2020). Improvement in Productivity and Profitability of Sugarcane Through Drip Fertigation in North Indian Conditions. *Sugar Tech,* 1-10 https://doi.org/10.1007/s12355-020-00924-w.	7.87
38.	Singh K., Choudhary OP., Singh HP., Singh, A. and Mishra, SK. (2019). Sub-soiling improves productivity and economic returns of cotton-wheat cropping system. *Soil & Tillage Research*, 189:131-136.	13.37
39.	Singh R., Mavi MS. and Choudhary OP. (2019). Saline soils can be ameliorated by adding biochar generated from rice-residue waste. *CLEAN-Soil Air Water*, 47: 1700656 *(1-9). doi:10.1002/clen.21700656.*	8.40
40.	Singh V., Kaur S., Singh J., Kaur A. and Gupta RK. (2020). Rescheduling fertilizer nitrogen topdressing timings for improving productivity and mitigating N_2O emissions in timely and late sown irrigated wheat (*Triticum*	8.24

	aestivum L.). *Archives of Agronomy and Soil Science*. DOI: 10.1080/03650340.2020.1742327.	
41.	Singh P., Singh G., Sodhi GPS. and Sharma S. (2021). Energy optimization in wheat establishment following rice residue management with Happy Seeder technology for reduced carbon footprints in north-western India. *Energy*, 230:120680.	14.86
42.	Singh V., Sharma K., Gosal SK., Choudhary R., Singh R., Adholeya A. and Singh B. (2020). Optical Sensing and Arbuscular Mycorrhizal Fungi for Improving Fertilizer Nitrogen and Phosphorus Use Efficiencies in Maize. *Journal of Soil Science and Plant Nutrition*. https://doi.org/10.1007/s42729-020-00277-z .	9.61
43.	Tater, A., and Vashisht, B. B. (2024). Long-Term Effect of Crop Establishment Methods and Tillage Practices on Soil Physical Properties in Rice-Wheat System. *Communications in Soil Science and Plant Analysis*, 55(11), 1613-1628.	7.80p
44.	Varinderpal-Singh., Kunal., Gosal SK., Rita Choudhary., Reena Singh. and Alok Adholeya. (2021). Improving nitrogen use efficiency using precision nitrogen management in wheat (*Triticum aestivum* L.). *Journal of Plant Nutrition and Soil Science,* 184: 371-377.	8.57
45.	Varinderpal-Singh., Kunal., Gosal SK., Rita Choudhary., Reena Singh. and Alok Adholeya. (2021). Arbuscular mycorrhizal fungi and proximal sensing for improving nutrient use efficiencies in wheat (*Triticum aestivum* L.). *Journal of Plant Nutrition*. DOI:10.1080/01904167.2021.2014872.	8.28
46.	Varinderpal-Singh., Kuna.l, Rajinder Kaur., Mehtab-Singh., Mohkam Singh., Harpreet-Singh. and Bijay-Singh. (2021). Prediction of grain yield and nitrogen uptake by basmati rice through in-season proximal sensing with a canopy reflectance sensor. *Precision Agriculture*. doi.org/10.1007/s11119-021-09857-0.	11.77
47.	Varinderpal-Singh, Kunal., Sharma S., Gosal SK., Choudhary R., Singh R., Adholeya A. and Bijay-Singh. (2020). Optical sensing and arbuscular mycorrhizal fungi for improving fertilizer nitrogen and phosphorus use efficiencies in maize. *Journal of Soil Science and Plant Nutrition,* 20: 2087-2098.	9.61
48.	Varinderpal-Singh., Navneet Kaur., Kunal., Blestar Singh., Jeewesh Kumar., Aman Thapar. and Eric S Ober. (2021). Nitrate leaching from applied fertilizer is reduced by precision nitrogen management in baby corn cropping systems. *Nutrient Cycling in Agroecosystems,* 120: 379-391.	9.87
49.	Varinderpal-Singh., Satwinderjit-Kaur., Jayesh-Singh., Kaur A. and Gupta RK. (2021). Rescheduling fertilizer nitrogen topdressing timings for improving productivity and mitigating N_2O emissions in timely and late sown irrigated wheat (*Triticum aestivum* L.). *Archives of Agronomy and Soil Science,* 67: 647-659.	8.24

50.	Varinderpal-Singh., Sharma S., Kunal., Gosal SK., Choudhary R., Singh R., Adholeya A. and Bijay-Singh. (2020). Synergistic use of plant growth-promoting rhizobacteria, arbuscular mycorrhizal fungi, and spectral properties for improving nutrient use efficiencies in wheat (*Triticum aestivum* L.). *Communications in Soil Science and Plant Analysis,* 51: 14-27.	7.58
51.	Vashsiht BB., Jalota SK., Ramteke P., Kaur R. and Jayeshwal DK. (2021). Impact of rice (*O. sativa* L.) straw incorporation induced changes in soil physical and chemical properties on yield, water and nitrogen–balance and –use efficiency of wheat (*T. aestivum* L.) in rice–wheat cropping system: Field and simulation studies. *Agricultural Systems*, 194: 103279.	12.77
52.	Vashisht BB., Maharjan B., Sharma S. and Kaur S. (2020). Soil quality and its potential indicators under different land use systems in the Shivaliks of Indian Punjab. *Sustainability*, 12:1-13.	9.89

Annexure III

S.N.	Application Name	Year of development	URL of the application	Objective	Beneficiaries	Platform
1	Launch of PAU Urea Guide Mobile App	2019	Downloaded free of cost from Google play store or Apple App store	A decision support system for need-based fertilizer N use in field crops App will help farmers to achieve potential yields with minimum use of fertilizer urea and thus higher economic benefits. The reduced consumption of urea will also mitigate ground water and air pollution	More than 11700 farmers have downloaded the App	https://play.google.com/store/apps/details?id=com.pau.soils&hl=en_IN&pli=1

Annexure IV

Autonomous Paddy Transplanter in Puddled Field

The prototype of remotely controlled system has been designed and developed for walk behind type paddy transplanter to reduce the physical and psychological workload of operator. The increase in effective field capacity was observed up to 20%, resulting the net benefit per unit area and per year has been increased by 6.6% and 15.9% respectively. The overall results of the field evaluation showed that the remote-controlled system for two-wheel paddy transplanter would be feasible at optimized field and machine parameters.

The preliminary laboratory and field testing have been completed.
Fine tuning, modifications and field experiment of the developed system is under progress.

Patent filed: 01
An Autonomous System for 2-Wheel Paddy Transplanter.
Patent Application No. : 202111019252

Annexure V

Gargi Sharma
Ph.D Soil Science
Department of Soil Science

"I consider myself privileged to be a part of NAHEP-CAAST and will be able to utilise this experience in my future career"

International training as a springboard for exposure

I am a Ph.D. Scholar from Punjab Agricultural University, pursuing my degree in soil science under the guidance of Dr. O.P. Choudhary. My educational background includes a Master's degree in Soil Science from Dr YSP University of Horticulture and Forestry, Solan, India and Undergraduate studies in Agriculture from Rajasthan Agricultural University, Bikaner, India.

Since I became a part of NAHEP-CAAST project, I got opportunity to attend many lectures, workshops and training programmes *viz.,* Training programme on "Statistical tools and database management in Agriculture" at PAU Ludiana in collaboration with ICAR Indian Agricultural Statistics Research Institute, New Delhi, lectures and training at PAU Ludhiana by Dr. Sandeep Kumar, Associate Professor, South Dakota State University, USA, Dr. Steve Grattan, Emeritus Scientist from UC Davis, California and Dr. Bhupinder Pal Singh, Principal Research Scientist from DPI, Australia under the programme "International visiting Professorships for mentoring PG students and young faculty of NAHEP-CAAST".

I also attended a 5 months international training as a visiting scholar at California State University (CSU), Fresno, USA under Dr. Sharon Benes in the Department of Plant Science under ICAR NAHEP CAAST project. The research project in which I worked in CSU, Fresno is entitled "*The Response of Alfalfa (Medicago sativa) Varieties to Saline, Sub-surface Drip Irrigation: Uniformity of Salinity Imposed, Dry Matter Yield and Sodium Accumulation".* Specifically, my main task was to optimize the extraction and analysis protocols for measuring sodium, potassium and boron in alfalfa shoot tissue. This involved learning the microwave acid digestion process and detection using an MP-AES. I also assisted with soil and plant tissue sampling in the field. This provided me a broader and comparative aspect of salinity and management practices on different crops in different soils and climatic conditions and I would be able to incorporate this experience to my current research work on rice-wheat cropping system irrigated with saline and sodic water. My experiences have led me to the conclusion that I am extremely satisfied with NAHEP, which I believe is giving university students a lot of chances and assisting them in becoming a better version of themselves.

JYOLSNA T
PhD Student
Department of Soil Science

I'm Jyolsna, a PhD student of Punjab Agricultural University. The NAHEP CAAST project was an excellent experience for me. I could attend lots of training programmes and workshops conducted on and off the campus. The series of lectures and training programmes conducted under the project helped me to enhance my knowledge in the subject and mould the researcher in me. The NAHEP project also gave me access to the resources I needed for my research. The main highlight of the project was the international training programme for 5 months. I got an opportunity to visit the University of Minnesota, USA and worked under Dr. David J. Mulla, who has extensive experience in crop modeling, applying geostatistics and remote sensing in agricultural systems. Under the guidance of Dr. Mulla, I learned about different soil-water crop models like DSSAT and HYDRUS. The knowledge in crop modelling helped me to simulate water and nitrogen dynamics in soil. I also got some experience in ArcGIS. Overall the project really motivated me to change my approach to research and academics.

Manjeet Kaur
Ph.D. Soil Science
Department of Soil Science

Step into new way of being

“It was a crucial step in my personal transformation. NAHEP-CAAST provided me the platform to know who I was and who I could be. I am fortunate to be a part of NAHEP-CAAST project.”

I am Manjeet Kaur, a Ph.D. Scholar in the Department of Soil Science working on “Quantification and mitigation of agricultural greenhouse gas emissions” under the guidance of Senior Soil Chemist Dr GS Dheri. Being a part of ICAR-NAHEP-CAAST project, I got an opportunity to visit ‘Carbon Management and Sequestration Centre (C-MASC)’, The Ohio State University, Columbus, USA from March 13, 2020 to July 17, 2020. At C-MASC, I worked on ‘Management of soil carbon and greenhouse gas emissions’ under the supervision of most renowned Soil Scientist and World Food Prize 2020 Laureate Dr Rattan Lal. It was a great honour for me to be a part of C-MASC. I enjoyed taking part in discussions on the different aspects related to soil health and soil quality with Dr. Rattan Lal and his team. Those discussions really helped me in developing and mainstreaming a soil-centric approach for climate change mitigation. I gained and enhanced analytical and instrumentation experience on greenhouse gas emissions and carbon sequestration during this training program. I also got a chance to interact with the research scholars from different countries. Working at an amazing institute with friendly environment was great and unforgettable experience.

Through my visit, I have not only benefitted academically but this visit has contributed to my personal development too. Most of us are held back by limiting beliefs: untrue thoughts we have about our intrinsic nature and I was one of them. This opportunity pushed me forward and helped to find the person who really, I am. Stepping out of my comfort zone during uncertain COVID-19 pandemic helped me to let go of whatever limiting beliefs that were keeping me from becoming the best version of myself.

Sometimes the smallest step in the right direction ends up being the biggest step of your life and I think being a part of NAHEP-CAAST and PAU, Ludhiana is that step. I am thankful to NAHEP-CAAST and Punjab Agricultural University, Ludhiana for providing me this opportunity.

I wish you all great health, happiness and prosperity

Raagjeet Kaur
Ph.D. Soil Science
Department of Soil Science

"I believe that NAHEP-CAAST has provided remarkable incentives to build my academic and research skills, expanded my vision, and helped me become a better version of myself."

I am a Ph.D. scholar from the department of Soil Science, Punjab Agricultural University, Ludhiana, working under the guidance of Dr. M. S. Mavi (Senior Soil Chemist). So far, NAHEP-CAAST project has been a wonderful experience for me. Under this project, I got to attend a series of guest lectures, workshops and training programs. To name a few- A five day workshop on statistical tools and database management in agriculture, and guest lectures by International speakers namely Dr. Steve Grattan (Emeritus Scientist, UC Davis, California), Dr. Sandeep Kumar (Associate Professor, South Dakota State University, USA) and Dr. Bhupinder Pal Singh (Principal Research Scientist from DPI, Australia), Felicitation program and webinar by Dr. Rattan Lal (World Food Prize Laureate). The best part of the project for me was the International training that gave me an international exposure. I have attended a five month international training under NAHEP-CAAST at Colorado State University, Fort Collins, USA, from 15th March 2020 to 17th July 2020, under the guidance of Dr. Francesca Cotrufo. I engaged in laboratory activities and gained experience on the size and density fractionation of organic matter into Particulate organic matter and Mineral-associated organic matter (light and sand-sized, silt-sized and clay-sized fraction), soil preparation for PLFA analysis, worked with carbon and nitrogen isotopes enriched rhizospheric soil samples from an incubation study in Kansas and assisted in soil processing and root extraction. This training provided me with good experience and I can apply some of the things I learnt in my current as well as future research work. Apart from that, NAHEP-CAAST project provided high-tech laboratory instruments which facilitated my research work. Summing up, I consider myself to be fortunate to able to work under NAHEP-CAAST, as it provided me with valuable opportunities and resources that gave me a lot of exposure, enhanced my knowledge and skills and moreover, motivated me to improve and be more confident as a researcher. I am really thankful to NAHEP-CAAST for providing me with this opportunity.

PADMA ANGMO

Ph.D. Soil Science
Department of Soil Science

"I believe that NAHEP-CAAST has been a life changing opportunity to build my academic and research skills, it has been a very productive training which enhanced my understanding about SOIL like never before."

I am a Ph.D. scholar from the department of Soil Science, Punjab Agricultural University, Ludhiana, working under the guidance of Dr. Sandeep Sharma Microbiologist (Soil). Through the NAHEP-CAAST project, I got a golden opportunity to attended a two-month international training under NAHEP-CAAST at University of Nebraska, Lincoln USA, from 8th Feb 2022 to 30th March 2022, under the guidance of Dr. Javed Iqbal. This training was a new learning experience despite short term. The campus ambience was excellent and the laboratories was full of advance high-tech machines. I have learned new techniques for nitrification and soil column study by microplate method which is useful in soil enzyme studies. I got to learn many new skills and work on high-tech machines. I have visited the Steward Laboratory & Larsen Tractor museum at the University of Nebraska. I also got the opportunity to visit South Dakota State University, where I have learned about Phospholipids fatty acid extraction, Microbial biomass Carbon and Nitrogen, Hot-water extractable, and cold-water extractable carbon for soil analysis. I got to interact with many professors and research scholars from different parts of the world and exchange ideas. Because of this training, I got more interested in research in Soil Science and would like to apply for Postdoctoral.

Lastly, I would like to thank NAHEP-CAAST for providing me this opportunity through which I have enhanced my communication and writing skills, learning about new software and a chance to interact with many scientist and researcher which build my confidence as a researcher.

TARANDEEP KAUR
Ph.D. Agronomy
Department of Soil Science

"***When dreams turn into reality***"
I have always had a dream to study in abroad and to explore their high-tech technologies related to agriculture. NAHEP-CAAST provided me this opportunity for fulfilling my long-cherished desire.

I am a Ph.D. scholar from the department of Agronomy, Punjab Agricultural University, Ludhiana, working under the supervision of Dr. P.K. Sharma (Principal Agronomist). From this project, I got the opportunity to attend international training at Mississippi State University, Mississippi, USA in March, 2022 under the guidance of Dr. Gurpreet Kaur and Dr. Gurbir Singh. It was a really great pleasure to attend this training. I genuinely enjoyed each and every moment of it. This training programme helped me to gain experience of latest statistical tools and field technologies. I also gained knowledge about whinrhizo root scanner and tactics of operating growth chambers. I took part in discussions, field visits and events. It opened up a different dimension to my training, allowing me to explore more ground and motivated me to do more. I also interacted with many scientists and research scholars from around the globe, which helped me to know their culture as well as to exchange ideas. The training motivated me to further pursue studies as a post doc. At last, I would like to thank to all people associated with NAHEP-CAAST project for providing me this wonderful opportunity for enhancing my knowledge.

Dr. Shiv Kumar Lohan

Scientist, Farm Machinery & Power Engineering

"Being a part of NAHEP, I could be familiar with the recent advances in artificial intelligence and robotics in agriculture"

An initiative towards a new era of AI and robotics in agriculture

Dr. Shiv Kumar Lohan, Scientist from Deptt. of Farm Machinery & Power Engineering, visited at Washington State University, Prosser (USA) as Visiting Scholar during his in-service PhD Programme. He feels his gratitude to NAHEP for providing him this opportunity.

Dr. Lohan – a challenging- self initiated person, was driven to join the scholarship programme during global COVID- lockdown days. He appreciated the work culture, university facilities, comfortable environment to achieve the knowledge and exposure on the ongoing research projects on precision farming and robotics in agriculture.

He initiated to be exposed with the various sensors, camera is being used in Unmanned Aerial Systems (UAS) for crop sensing for development of integrated robotic systems in agriculture. Adding on to this, he got familiar with the various hardwares machines and equipment, viz. arduino micro-controller and raspberry micro-computer, controlling of electric actuators/ motors, cameras and sensors, RGB camera (Zed), 3-D camera (Kinect, real sense), Multispectral camera; 5-band (MicaSense Red-Edge 3), Hyperspectral camera, thermal cameras (Raspberry Pi and smart phone enabled) etc. He wishes to utilizes the acquired tremendous knowledge and his technical skills for implementing the robotics and agriculture technology in Indian farm mechanization.

He shared that he was considered a self-initiated and collaborative nature of person and found willingness to help others and seek support from the available resources. Dr. Lohan's mentor tagged him as a highly motivated, enthusiastic and creative researcher and thankful to him for considering WSU CPAAS for his substantial contribution to their research programme.

Dr. Om Prakash Choudhary

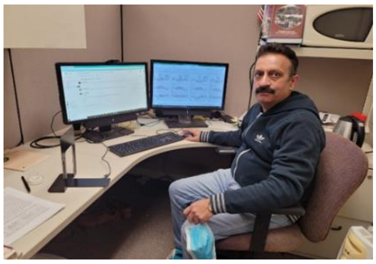
Principal Soil Chemist/PI, NAHEP CAAST- School of Natural Resources Management

Participating in the NAHEP CAAST program was an incredible privilege that opened doors to international training experiences at renowned universities across the globe. One such remarkable opportunity came my way when I was selected as a visiting scholar from July 05 to August 18, 2022, at the prestigious University of California, Davis (UCD) in the United States. This endeavour turned out to be a significant milestone in my academic journey.

During my time at UCD, I was fortunate enough to engage in a myriad of enriching activities and experiences. One of the highlights was the chance to establish research and teaching collaborations with the esteemed Department of Land, Air, and Water in UCD's campus at Davis. Specifically, our collaborative efforts were focused on the vital subject of sustainable nutrient and water management.

Dr. Bharat Bhushan Vashisht

Principal Soil Physicist/Co-PI, NAHEP CAAST- School of Natural Resources Management



It was a great opportunity provided by NAHEP CAAST to have international trainings in the reputed Universities of the world. It was a significant achievement while visiting University of Minnesota, Twin Cities Campus, St. Paul, MN, USA as visiting Scholar from Feb. 16 to March 24, 2022. University of Minnesota ranked at No. 40 in the world, placing the University in the top 2 percent globally. I got the opportunity to work in the Precision Agriculture lab in the Department of Soil, Water & Climate under the direction of Dr. David J. Mulla, Professor, and Director, Precision Agriculture Center, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota. I was provided training on soil water transport modeling using Hydrus-1D, which includes learnings of –

- how to estimate soil moisture thresholds using long-term monitoring data
- how to estimate soil hydraulic parameters for the Van Genuchten-Mualem model using several different software programs
- how to use Hydrus-1D for soil water and solute transport modeling
- how to select upper and lower boundary conditions across a range of soil types,
- how to set soil profile initial conditions, and how to estimate infiltration, percolation, solute transport and changes with depth and time in soil moisture content, soil matric potential, and solute concentration.
- learned how to produce tabular and graphical outputs for the above parameters with the Hydrus-1D model.

This visit would be helpful in continuing research collaboration with Dr. David J. Mulla, University of Minnesota through scientific research, research publications and scientific workshops with Punjab Agricultural University.

Dr. Manpreet Singh Mavi

Principal Soil Chemist/Co-PI, NAHEP CAAST- School of Natural Resources Management

Worked as a Visiting Scientist in the Soil Biogeochemistry Lab of Dr Steven Hall, Associate Professor, Department of Ecology, Evolution, and Organismal Biology, Iowa State University, USA for 3 months from June to September 2023 under International Training programme of ICAR-NAHEP-CAAST-SNRM. I had a wonderful experience working with multitalented team of students, post-docs and scientists in the Soil Organic Matter group on GHG emissions and Isotopic analysis of soil samples. Field visits were undertaken to Bio Century Research Farm and Smeltzer Research farm to enhance understanding about different experiments conducted by the group members. During my visit, I also visited the Pyrolysis production facility for the production of biochar in the Department of Agricultural & Biosystem Engineering. Overall, a fruitful experience and a pious beginning for future collaborative work with some creative minds on scientific pursuit in Soil Science.

Dr Gurmeet Singh Dheri
Senior Soil Chemist

"NAHEP, a fantastic opportunity to work at a dream institution worldwide to improve professional skills in preparation for zero-emission agriculture."

Dr GS Dheri, a Senior Soil Chemist, is incharge of the ICAR-funded project on the Long-Term Fertilizer Experiment at Punjab Agricultural University (PAU), Ludhiana, Punjab, India. His study focuses on the effects of long-term fertilizer and manure application on soil quality, crop production, and greenhouse gas emissions in a maize/rice-wheat system. Dr Dheri is evaluating the carbon (C) sequestration rates and GHGs emissions under different fertilizer, crop residue, tillage, and irrigation regimes at PAU.

He went to Ohio State University in Columbus, USA, and worked with Dr Rattan Lal at the Carbon Management and Sequestration Center (C-MASC). ICAR supported his trip through the National Agricultural Higher Education Project (NAHEP) and the Centre of Advanced Agricultural Science and Technology (CAAST). Dr Dheri expressed his gratitude for the opportunity to work at the Carbon Management and Sequestration Center (C-MASC) under the guidance of Dr Rattan Lal, calling it "a matter of pride and a great honour."

Soil carbon management and greenhouse gas emissions under biofuel crops were his primary research areas at C-MASC. Using a greenhouse experiment, he examined the relationship between residue management and greenhouse gas emissions in the soil air under maize. Dr Dheri also attended seminars and lectures at C-MASC to learn more about its educational and research programmes. Dr Dheri remarked, "Working with Dr Lal and his team has been a good experience since they have provided me with opportunities to expand my knowledge of soil science and strengthen my analytic talents." NAHEP programmes are an excellent opportunity for researchers in India to improve their knowledge and professional competencies in their field of study, allowing them to address current issues for the sustainable development of agriculture and society.

Dr. Sandeep Sharma

Microbiologist (Soils)

"**I am glad to have access to a platform where faculty can drive new interest, collaborative projects and enhance their vision**"

Diving deeper into natural processes and concepts

Sandeep Sharma, Microbiologist (Soils) visiting professor in the Department of Agronomy and Horticulture, University Nebraska-Lincoln, USA to know about nitrate leaching process, their measurement methodology and some modern biological techniques (FAME, PLFA and Molecular). The biggest advantage of the training was to learn from the peoples who were involved in the same back round. We were able to relate to them better in term of doubts regarding different nitrogen transformation processes under different residue and nitrogen management practices.

I not only got to learn about the subject but also got look at thinks from perspective. I am wishes that NAHEP continues to organized similar activities in future for more duration that helps the faculty as well as University to established new structure and facilities.

Annexure VI

Subject areas	***Period of training, total beneficiaries***	***Output of the training***
Students		
Ms. Jyolsa T., a PhD student of Deptt of Soil Science attended a, jointly organized by University of California, USA and IIT Mandi at IIT Mandi	*September 9-11, 2019*	*Specialized training on Applications of HYDRUS model*
Ms. Amina Raheja had undergone training on at Jamiia Millia Islamia University, New Delhi	*January 27-February 27, 2020*	*Development of capacitance based sensor Soil Moisture Sensor*
Mr. Susanta Das had undergone training on at Jamiia Millia Islamia University, New Delhi	*January 27-February 27, 2020*	*Development of capacitance based sensor Soil Moisture Sensor*
Mr. Shiv Kumar Lohan, a PhD student of Deptt of Farm Machinery & Power Engineering visited Central Institute of Agricultural Engineering, (CIAE), Bhopal	July 04-05, 2019	*To study the measurement actuating force on the hand levers of farm machineries & IIT Kharagpur*
Mr. Shiv Kumar Lohan, a PhD student of Deptt of Farm Machinery & Power Engineering visited to IIT Kharagpur	July 21-22, 2019	Learning the installation of electronic actuators to control the hand levers of tractors and other farm machineries
*Mr. Shiv Kumar Lohan, a PhD student of Deptt of Farm Machinery & Power Engineering attended three days virtual **ASABE Annual International meeting**/ conference of ASABE-2020*	*July 13-15, 2020*	
Mr. Shiv Kumar Lohan, a PhD student of Deptt of Farm Machinery & Power Engineering attended three days weekly virtual hands on training	*July 21, 30 and August 4, 2020*	*Arduino Hydroponic Workshop Series" at CPAAS, WSU, Prosser (USA)*
Faculty		
Dr. B.B. Vashisht, Co-PI, NAHEP CAAST attended a webinar on Drone Remote Sensing in Agriculture online organized by Division of Agricultural Physics, ICAR-IARI, New Delhi	*September 20, 2020*	*Learning on the prospective uses of Drone in managing natural resources*
Dr. B.B. Vashisht, Co-PI, NAHEP CAAST attended a one-day webinar-cum-training	*December 08, 2021*	*Advance methods/software/equations were discussed for studying different soil*

programme on Modelling Soil Physical Processes for Improving Resource Use Efficiency in Agriculture online organized by Division of Agricultural Physics, ICAR-IARI, New Delhi		*physical processes for managing natural resources*

Attended Annual Technical Review Meeting 2023 of NAHEP-CAAST held at Kerala Agricultural University, Thrissur

Green and Clean Campus Award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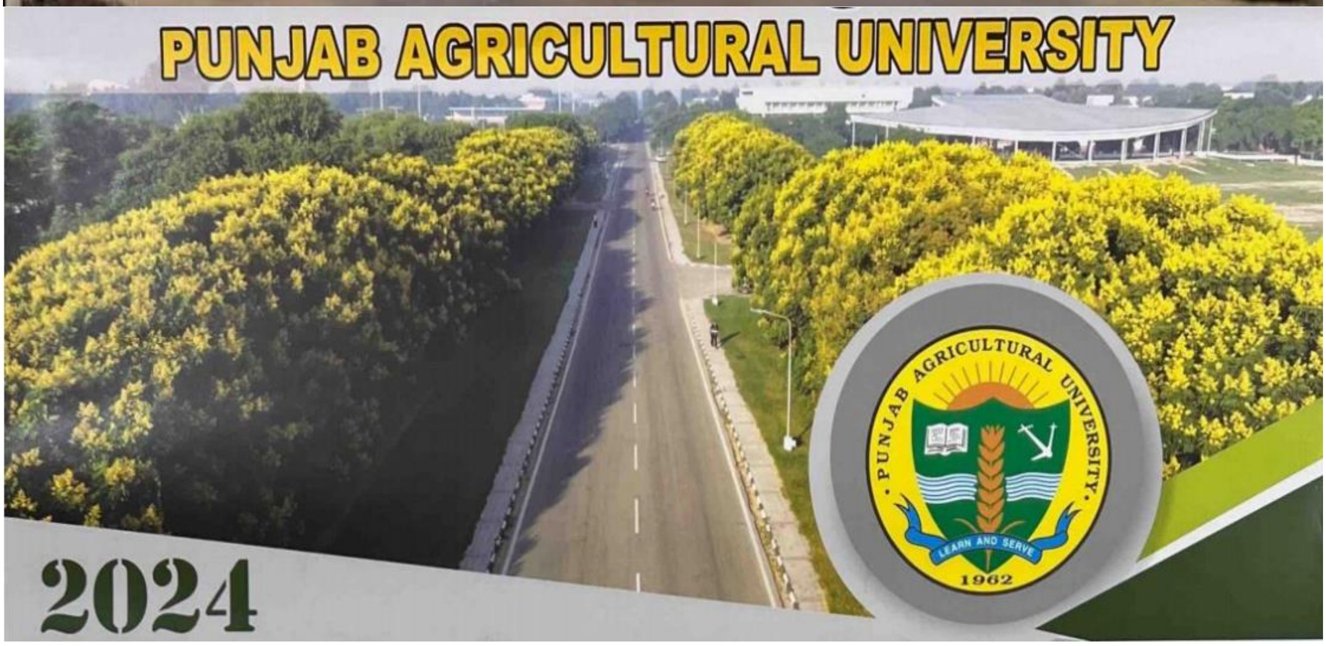
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