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भाकृअनुप ICAR

वार्षिक विवरणिका

ANNUAL REPORT

2021-22

भाकृअनुप-केन्द्रीय कृषि अभियांत्रिकी संस्थान
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ICAR-CENTRAL INSTITUTE OF AGRICULTURAL ENGINEERING
Nabi Bagh, Berasia Road, Bhopal- 462038

ICAR-CIAE

भाकृअनुप
ICAR

Indian Council of Agricultural Research

National Award of Excellence for Agricultural Institutions

SARDAR PATEL OUTSTANDING
ICAR INSTITUTION AWARD 2020
(Large Institute)

is presented to

ICAR–Central Institute of Agricultural Engineering, Bhopal

16 July, 2021
New Delhi

(T. Mohapatra)
Secretary (DARE)
Director General (ICAR)

(Narendra Singh Tomar)
Union Minister of Agriculture & Farmers Welfare
Govt. of India

ICAR- CIAE

वार्षिक विवरणिका
ANNUAL REPORT
2021-22

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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PREFACE

The country is yet to be done with COVID-19, and the aftermath has pushed up the problem of hunger, poverty, unemployment, and malnutrition. This has put tremendous pressure on the agri-food system, which is already reeling under the problem of climate change, paucity of the labourer, and food loss, limiting their proper functioning. It is worthwhile to mention that despite all the odds, the agriculture sector has stood tall in the face of current adversities, bringing out the importance of mechanisation in agriculture and safe food for the survival of mankind. Resonating with the motto of "Jai Kishan, Jai Vigyan and Jai Anushandhan", the ICAR-Central Institute of Agricultural Engineering has been ardently promoting pre- and post- production mechanisation in agriculture, efficient resource utilisation, losses reduction and processing and value addition of agricultural produce through its research and development activities.

During the year 2021-22, the Institute focussed on technologies that would limit human-human interaction to prevent the COVID-19 like catastrophe, reduce drudgery, and tackle food waste through the sensor, IoT and AI-based technologies, precision agriculture, mechanisation of field and orchard crops, post-harvest processing and value addition of horticultural and medicinal crops, renewable energy utilising gadgets, harnessing solar energy, value addition to biomass, and optimum water utilisation through protected cultivation, and micro-irrigation. The Institute is making conscious efforts to develop a complete mechanisation package and value chain for different crops and cropping systems through individual effort and partnering with different commodity based institutes. The developed technologies pertaining to the crops of national importance, such as rice, wheat, millets, legumes, onion, garlic, potato, orchard crops like Litchi and grapes, and cash crops such as sugarcane, and tobacco, are rigorously tested and being commercialised. Furthermore, the Institute addressed the energy issues in agriculture through biomass utilisation, harnessing solar energy and exploring possibilities to extract oil from the non-conventional source like microalgae. Processing machinery and technology development activities has focussed on the drudgery reduction, operator's comfort, losses prevention and food safety, leading to development of sensor based, ergonomically designed, safe storage and environment friendly technologies for horticultural, medicinal and cash crops, millets, legumes and by-products from the food processing industries.

Four All-India Coordinated Research Projects and two Consortia Research Projects operating across the country have come out with location and crop-specific, need-based solutions. These technologies are being demonstrated and undergoing rigorous testing across the country.

The easing of restrictions due to COVID-19 has witnessed physical as well as virtual participation of the stakeholders in different events organised by the institute. During 2021, the institute organized 57 training programmes/workshops/seminars/webinars/interaction meets/review meetings. Since virtual meetings have become a norm and brought people across the world together, several webinars were organised as part of several programs like Azadi ka Amrut Mahotsav, and most of the internal meetings were conducted in virtual mode. During this year, 4689 prototypes, worth Rs. 78,20068/- were supplied, and 51 commercial equipment manufactured by Industries were tested. Our staff and students brought several accolades and recognition from professional bodies for their contribution to the profession.

I am indebted to Hon'able Secretary, DARE and Director General, ICAR, Dr. Trilochan Mohapatra, for his constant guidance. Sincere thanks are due to Dr. Alagu Sundaram, Former Deputy Director General (Agricultural Engineering), ICAR; Dr. S K Chaudhari, Former Deputy Director General (Agricultural Engineering), ICAR; Dr. S N Jha, Deputy Director General (Agril. Engg.), ICAR and Dr Kanchan Kumar Singh, Assistant Director General (FE), for their unwavering support and guidance to the Institute in executing R&D and other activities presented in this annual report. The administrative and financial support received from the ICAR headquarter is gratefully acknowledged. The achievements presented in this report are due to the dedication and persistent efforts of the staff during the pandemic and post-pandemic period and need special mention. This annual report is put forth with the hope that it provides valuable input to different stakeholders. I also thankfully acknowledge the annual report editorial team's contribution for their commitment to bring out this report.

CONTENTS

कार्यकारी सारांश

इस वर्ष के दौरान, भाकृअनुप-केंद्रीय कृषि अभियांत्रिकी संस्थान, भोपाल ने फसल उत्पादन और उत्पादन के बाद की प्रक्रियाओं के मशीनीकरण, मूल्य वर्धित उत्पादों और प्रक्रियाओं के विकास, प्रौद्योगिकियों के हस्तांतरण, प्रौद्योगिकियों को लोकप्रिय बनाना, और मानव संसाधन के विकास से संबंधित विभिन्न अनुसंधान और विकास गतिविधियों का संचालन किया है। इसके क्षेत्रीय केंद्रों, सीआरपी और एआईसीआरपी के साथ संस्थान की गतिविधियाँ जैसे- नए उपकरणों और गैजेट्स का विकास, पहले से विकसित प्रौद्योगिकियों का मूल्यांकन और शोधन, नवीन मूल्य वर्धित उत्पादों और प्रक्रियाओं का विकास, अध्ययन/सर्वेक्षण आयोजित करना, हितधारकों को सफल प्रौद्योगिकियों का हस्तांतरण, आई.पी.आर., प्रशिक्षण, स्नातकोत्तर शिक्षण, अनुसंधान, और प्रकाशन किया है। इस अवधि के दौरान की गई प्रमुख उपलब्धियां और घटनाओं का सारांश निम्नलिखित खंड में दिया गया है।

नव विकसित उपकरण/मशीनरी/प्रौद्योगिकियां

नए उपकरण और मशीनरी

- **ट्रैक्टर संचालित प्लास्टिक मल्च लेयर-सह प्लांटर:** यह मशीन रेजड-बेड बनाने, ड्रिप लेटरल, प्लास्टिक मल्च बिछाने और तरबूज, मक्का, प्याज, लेतिष, हरी मटर, भिंडी, बीन्स आदि लगाने के लिए उपयुक्त है। उपकरण की क्षेत्र क्षमता और क्षेत्र दक्षता 0.47 मीटर/सेकंड की गति के साथ क्रमशः 0.2 हेक्टेयर/घंटा और 74% है।

- **चावल और गेहूं की फसलों के लिए उर्वरक अनुप्रयोगक (एप्लीकेटर) के साथ ट्रैक्टर चालित आठ-पंक्ति प्रिसिशन न्यूमेटिक (सटीक वायुवीय) हिल ड्रॉप प्लांटर:** इसकी क्षेत्र क्षमता और क्षेत्र दक्षता चावल के लिए क्रमशः 0.42 हेक्टेयर/घंटा और 70.36 प्रतिशत और गेहूं के लिए 0.44 हेक्टेयर/घंटा और 73.04% है।

- **अरहर के लिए न्यूमेटिक (वायुवीय) सीड ड्रिल:** मैनुअल, बैल-चालित और ट्रैक्टर-चालित न्यूमेटिक सीड ड्रिल की क्षेत्र क्षमता और क्षेत्र दक्षता क्रमशः 0.09, 0.13, 0.50 हेक्टेयर/घंटा और 70, 80 और 80% है।

- **ट्रैक्टर चालित तम्बाकू पौधा प्रत्यारोपण मशीन पानी के स्पॉट अनुप्रयोग के साथ:** उपकरण की क्षेत्र क्षमता और मिसिंग प्रतिशत 0.42 मीटर/सेकंड की गति के साथ 0.2 से 0.3 हेक्टेयर/घंटा और 2-3% है।

- **गुणक प्याज के लिए ट्रैक्टर चालित रेजड बेड फॉर्मर-सह-प्याज सेट प्लांटर:** उपकरण की क्षेत्र क्षमता और क्षेत्र दक्षता क्रमशः 0.30 हेक्टेयर/घंटा और 75% है।

- **ट्रैक्टर चालित अरहर की रोपाई यन्त्र जो पंक्ति से पंक्ति और पौधे से पौधे की दूरी को समयोजित कर सकता है :** ट्रांस्प्लान्टर की क्षेत्र क्षमता और क्षेत्र दक्षता 8% की व्हील स्लिप के साथ क्रमशः 0.13 हेक्टेयर/घंटा और 76% है।

- **गन्ना कुरमुला (व्हाइट ग्रब, सफ़ेद गीडार) प्रबंधन के लिए छोटे ट्रैक्टर से संचालित ईपीएन अनुप्रयोगक:** इस उपकरण की क्षेत्र क्षमता 0.18 हेक्टेयर/घंटा है।

- **रेजड-बेड के लिए ट्रैक्टर चालित लहसुन-पुत्थी डिब्लर:** उपकरण की क्षेत्र क्षमता, क्षेत्र दक्षता, मिसिंग और गुणक 0.56 मीटर/सेकेंड की गति के साथ क्रमशः 0.22 हेक्टेयर/घंटा, 73.6%, 3.5 और 8.5% हैं।

- **निकट दूरी वाली प्याज की फसलों के लिए चार-पंक्ति स्व-चालित प्याज वीडर:** मशीन की क्षेत्र क्षमता, क्षेत्र दक्षता और निराई दक्षता 0.34 मीटर/सेकंड की गति के साथ क्रमशः 0.06 हेक्टेयर/घंटा, 85% और 93%, है।

- **लीची के लिए सुरक्षा सलंग्नक के साथ एर्गोनॉमिक रूप से डिज़ाइन किया गया गर्डलिंग टूल:** संशोधित हैमर ड्रिल गर्डलिंग टूल, जिसका वजन 2 किलोग्राम है, जिसे हल्के से मध्यम रूप से भारी के रूप में वर्गीकृत किया गया है, इसमें 0.78 से 0.91 मीटर/सेकंड^2 का हाथ-बांह कंपन है।

- **लीची के पेड़ के लिए कैटरपिलर मारने के लिए मोटराइज्ड स्प्रेइंग टूल:** छिड़काव के 7 दिनों के बाद कैटरपिलर को खत्म करने में सिरिंज प्रणाली की तुलना में इसकी बेहतर दक्षता है।

- **रेजड-बेड के लिए ट्रैक्टर चालित लहसुन हार्वेस्टर:** 100 मिलीमीटर पंक्ति से पंक्ति और पौधे से पौधे की दूरी के लिए 0.54 मीटर/सेकंड की गति और 60-80 मिलीमीटर की गहराई में मशीन में प्रभावी क्षेत्र क्षमता और क्षेत्र दक्षता क्रमशः 0.21 हेक्टेयर/घंटा और 72% है।

- **ट्रैक्टर चालित एकीकृत कटाई-सह-संचारण मशीन:** मशीन की औसत काटने की ऊंचाई, प्रभावी क्षेत्र क्षमता और क्षेत्र दक्षता क्रमशः 0.42 मीटर/सेकेंड की गति से 66-80 मिलीमीटर, 0.19 हेक्टेयर/घंटा और 78% है।

- **रेजड-बेड , फ्लैट-बेड और रिज-फ़रो प्रणाली के लिए फ्रंट-माउंटेड अरहर हार्वेस्टर:** मशीन की क्षेत्र क्षमता, क्षेत्र दक्षता और काटने की दक्षता क्रमशः 0.3-0.55 हेक्टेयर/घंटा, 78-89% और 87-98% है।

- **ट्रैक्टर चालित जल निकासी ट्रेंचर:** मशीन 0.15-0.16 मीटर चौड़ाई और 1-1.1 मीटर गहराई की खाई बनाने और उप-सतह पाइप बिछाने के लिए उपयुक्त है। खुदाई के लिए 40-50% की लागत बचत के साथ मशीन की क्षेत्र क्षमता और क्षेत्र दक्षता 0.08 मीटर/सेकेंड की गति के साथ क्रमशः 250-365 मीटर/घंटा और 81% है।

- **सूक्ष्म सिंचाई प्रणालियों में उपयोग किए जाने वाले द्वितीयक फिल्टरों के मूल्यांकन के लिए परीक्षण व्यवस्था (टेस्ट-सेटअप):** प्रणाली का अधिकतम प्रवाह दर 19 मीटर^3/घंटा, टीएसएस लोड <1000 पीपीएम और 70 के.पीए. के दबाव पर इसकी औसत निस्पंदन दक्षता 31% है।

- **ब्रॉड-बेड-फ़रो में विकसित सोयाबीन फसलों में जलभराव वाले वर्टिसोल के लिए मोल जलनिकास तकनीक:** इसमें अस्थायी जलभराव वाले वर्टिसोल पर सोयाबीन की पैदावार 67-70% तक बढ़ जाती है, जिसकी लागत पाइप जलनिकास प्रणाली से कम होती है।

- **गेहूँ की फसल में पानी के दबाव के मूल्यांकन के लिए वर्णक्रमीय वनस्पति सूचकांक:** सामान्यीकृत अंतर जल सूचकांक और नमी तनाव सूचकांक, गेहूं की उपज के पूर्वानुमान के लिए पानी के तनाव का एक अप्रत्यक्ष आकलन प्रदान करता है।

- **छत के पानी के संचयन के लिए मोबाइल ऐप:** यह अनुकूलतम टैंक आकार की गणना करता है और वर्षा जल संचयन प्रणाली की विश्वसनीयता और जल-बचत दक्षता का विश्लेषण करता है। यह विभिन्न मापदंडों का भी आकलन करता है, जैसे कि अंतर्वाह मात्रा, भंडारण, रिलीज, स्पिलेज (टैंक ओवरफ्लो), न्यूनता, संचयी न्यूनता, संचयी मांग और न्यूनता दर।

- **कृषि संचालन के लिए सौर असिस्टेड ईप्राइम मूवर (एसएईपीएम):** इसमें खेत की दक्षता 82%, निराई दक्षता 70%, खेत की क्षमता 0.06 हेक्टेयर/घंटा और वीडर के संचालन के लिए 550 वाट की बिजली की आवश्यकता होती है।

- **संपीड़न इग्निशन (सीआई) इंजन ट्रैक्टर में संपीडित प्राकृतिक गैस (सीएनजी) की रेट्रोफिटिंग:** सीएनजी की खपत बिना लोड और रोटावेटर (1676 मिलीमीटर आकार) के संचालन के लिए खेत में क्रमशः 3.07 और 4.2 किग्रा/घंटा दर्ज की गई है।

- **पोर्टेबल डॉवंड्राफ्ट गैसीफायर:** इसका उपयोग स्क्रबिंग के लिए पानी के सक्रिय उपयोग के बिना कम टार उत्पादक गैस उत्पादन के लिए किया जाता है। गैस में टार की मात्रा 28-56 मिलीग्राम/नॉर्मल मीटर^3 की रेंज में होती है, जिसका ताप मान 5.1 - 6.9 मेगाजुल/मीटर^3 होता है। उत्पादक गैस की संरचना कार्बन मोनो-ऑक्साइड (CO): 16-24%, हाइड्रोजन (H_2):18-20%, मीथेन (CH_4): 2.7-6.7% और ऑक्सीजन (O_2): 3.4-7.7% है।

- **सूक्ष्म शैवाल से लिपिड्स का निष्कर्षण:** 17% की औसत लिपिड सामग्री के साथ 0.5 कि.ग्रा. सूक्ष्म शैवाल बायोमास से लिपिड निकालने के लिए सात लीटर एन-हेक्सेन का उपयोग किया जाता है, जबकि 65% विलायक (सोलवेंट) को पुनर्प्राप्त किया जा सकता है।

- **अरहर के डंठल से बायोक्रूड:** यह आसवन द्वारा 120 से 180 डिग्री सेल्सियस, 180 से 240 डिग्री सेल्सियस और 240 से 360 डिग्री सेल्सियस के तापमान की सीमा में उत्पन्न किया गया है, जिसमें फिनोल (दूसरे अंश से), टेट्राडेकेन और हेक्साडेकेन (तीसरे अंश से) शामिल है।

- **मोटर संचालित बेबी कॉर्न डीहस्कर:** इस मशीन का उद्देश्य कठिन परिश्रम को कम करना और नाजुक बेबी कॉर्न को छिलने की स्वच्छता में सुधार करना है। मशीन में 100% स्लिटिंग दक्षता, 92% डीहस्किंग दक्षता और 100% डीसिलिंग दक्षता है।

- **कटाई उपरांत उपचार मशीन:** 1-1.2 टन/घंटा की क्षमता वाली इस मशीन का उपयोग करके फलों और सब्जियों की निधानी आयु (शेल्फ लाइफ) को बढ़ाया जा सकता है। मशीन की परिचालन गति में बदलाव का प्रावधान वस्तुओं के 'उपचार के समय' में बदलाव की अनुमति देता है।

- **मशीन विज़न आधारित स्वचालित फल ग्रेडर:** इसका उपयोग फलों के वजन और दिखावट/रूप के आधार पर कुशल वर्गीकरण के लिए किया जाता है। फलों के वर्गीकरण के अलावा, मशीन पानी (गर्म/ठंडा) से धोने की संभावना भी प्रदान करती है।

- **औषधीय कंद (टूबर) फसलों के लिए छीलने की मशीन:** 18-20 किग्रा / घंटा की क्षमता वाली 3 एच.पी. मोटर द्वारा संचालित मशीन में सफेद मुसली के लिए 92% और शतावरी के लिए 55% छीलने की क्षमता है।

- **औषधीय कंद (टूबर) फसलों के लिए एर्गोनॉमिक रूप से डिज़ाइन किए गए पेडल-संचालित गुच्छो को हटाने (डी-बंचिंग) वाला उपकरण:** मशीन की क्षमता 11.28 कि.ग्रा./घंटा है, जिसमें 88% की डी-बंचिंग दक्षता है।

- **तंबाकू के पत्तों को सुखाने के लिए ऑन-फार्म-हीट-पंप-ड्रायर:** ऊर्जा कुशल पर्यावरण के अनुकूल ड्रायर नीरव (शोर-रहित) है और पारंपरिक सुखाने वाले खलिहान की तुलना में कम समय में समान रूप से रंगीन सूखे तंबाकू के पत्ते देता है।

- **सोयाबीन और काबुली चने से आहारीय रेशा (फाइबर) के निष्कर्षण के लिए प्रायोगिक संयंत्र :** यूनिट में प्रति बैच 10 किलो छिलके (हल्स) और 80% निष्कर्षण दक्षता की क्षमता है।

मूल्य वर्धित उत्पाद और प्रक्रियाएं

- **संक्रमित और गैर-संक्रमित आलू में भेद करने के लिए केमोमेट्रिक्स प्रोटोकॉल:** भंडारण के दौरान आलू द्वारा छोड़े गए वाष्पशील जैविक यौगिकों (वी.ओ.सी.) का विश्लेषण करके आलू के खराब होने का जल्दी पता लगाना संभव है।

- **अनाज भंडारण सामग्री के लिए काइटोसन कोटिंग:** कोटिंग ने यांत्रिक और बाधा दोनों गुणों में काफी वृद्धि की। ज्वार और बाजरा के लिए सबसे अच्छी पैकेजिंग सामग्री के रूप में काइटोसन-लेपित जूट बैग का सुझाव दिया जाता है।

प्रौद्योगिकी हस्तांतरण, प्रशिक्षण और क्षमता निर्माण

- लाइसेंस के माध्यम से 15 निर्माताओं को कुल 16 प्रौद्योगिकियों का व्यवसायीकरण किया गया। विभिन्न संगठनों के साथ 6 समझौता ज्ञापनों (एम.ओ.यू.) पर हस्ताक्षर किए गए।

- 4689 अनुसंधान प्रोटोटाइप की आपूर्ति की गई।

- 51 मशीनों का परीक्षण किया गया और राजस्व के रूप में ₹ 78.20 लाख की कमाई हुई।

- 57 प्रशिक्षण कार्यक्रम/ कार्यशालाएं/ सेमिनार/ बातचीत बैठकें/ समीक्षा बैठक आयोजित किये गए।

- एक पेटेंट अनुदत्त हुआ, सात पेटेंट के आवेदन दायर किए गए, एक कॉपीराइट पंजीकृत किया गया, और दो कॉपीराइट के आवेदन दायर किए गए।

- चार छात्रों को पीएचडी डिग्री प्रदान हुई, और 3 वैज्ञानिकों ने पीएचडी डिग्री प्राप्त की।

- संस्थान के 24 कर्मचारियों के विभिन्न प्रशिक्षण कार्यक्रमों में सम्मिलित हुए।

पुरस्कार और मान्यताएं

- **पुरस्कार:** सरदार पटेल उत्कृष्ट आईसीएआर संस्थान पुरस्कार 2020, आईएसएई पुरस्कार और अन्य

- **शोध पत्र, प्रकाशन:** इस वर्ष के दौरान 85 शोध पत्र, 30 पुस्तक और पुस्तक अध्याय, 8 तकनीकी बुलेटिन, 30 लोकप्रिय लेख, 5 विस्तार बुलेटिन और 4 तकनीकी रिपोर्ट प्रकाशित किए गए।

आयोजन

वर्ष के दौरान आयोजित कुछ कार्यक्रमों जैसे की आईसीएआर क्षेत्रीय समिति की 26वीं बैठक, कृषि मशीनीकरण में आत्मनिर्भर भारत के लिए रणनीतियों पर मंथन सत्र, कृषि इंजीनियरिंग में स्वचालन, एआईसीआरपी की वार्षिक कार्यशालाएं, आरएसी बैठक, विश्व जल दिवस समारोह, अंतर्राष्ट्रीय महिला दिवस समारोह, अंतर्राष्ट्रीय योग दिवस, हिंदी में राष्ट्रीय सम्मेलन, 'कृषि इंजीनियरिंग हस्तक्षेपों के माध्यम से महामारी में लचीलापन और मुकाबला रणनीतियाँ: महिला परिप्रेक्ष्य' पर राष्ट्रीय वेबिनार, "दीर्घकालिक सुरक्षित भंडारण के लिए स्मार्ट अनाज प्रबंधन प्रौद्योगिकी" पर राष्ट्रीय वेबिनार, "रोडमैप ऑन मध्य प्रदेश राज्य में कृषि मशीनीकरण", "शुरू से ही सही खाएं", "ड्रोन-आधारित हाइपर-स्पेक्ट्रल इमेजिंग का उपयोग करके फसल के मुद्दों का प्रारंभिक निदान", "बागवानी में पोस्ट-हार्वेस्ट गुणवत्ता नियंत्रण और मूल्य श्रृंखला", "कृषि और पर्यावरण": द सिटीजन फेस", कृषि यंत्र निर्माता दिवस, आदि शामिल हैं।

EXECUTIVE SUMMARY

During this year, the ICAR-Central Institute of Agricultural Engineering, Bhopal, has conducted various research and development activities related to the mechanisation of crop production and post-production processes, the development of value-added products and processes, transfer of technologies, the popularisation of technologies, and human resource development. The activities of the Institute along its Regional Centers, CRPs and AICRPs, have been summarised as the development of new equipment and gadgets, evaluation and refinement of previously developed technologies, development of innovative value-added products and processes, conducting studies/surveys, transfer of successful technologies to stakeholders, IPR, training organised, post-graduate teaching, research, and publications. Salient achievements and a summary of the events carried out during this period are given in the following sections.

New Equipment/ Machinery/Technologies developed

New Equipment and Machinery

- **Tractor-operated plastic mulch layer-cum planter:** This machine is suitable for raised bed forming, drip lateral and plastic mulch laying and planting watermelon, corn, onion, lettuce, green peas, okra, beans, etc. The field capacity and field efficiency of equipment are 0.2 ha/h and 74%, respectively, at a forward speed of 0.47 m/s
- **Tractor-drawn eight-row precision pneumatic hill drop planter with fertiliser applicator for rice and wheat crops:** Its field capacity and field efficiency are 0.42 ha/h and 70.36% for rice and 0.44 ha/h and 73.04% for wheat, respectively.
- **Pneumatic seed drills for pigeon pea:** The field capacity and field efficiency of manual, bullock-drawn and tractor-drawn pneumatic seed drills are 0.09, 0.13, 0.50 ha/h and 70, 80, and 80%, respectively.
- **Tractor-operated tobacco seedling transplanter with spot application of water:** The field capacity and missing percentage of equipment are 0.2 to 0.3 ha/h and 2-3% at 0.42 m/s working speed.
- **Tractor-operated raised bed former-cum-onion set planter for multiplier onion:** The field capacity and field efficiency of equipment are 0.30 ha/h and 75%, respectively.
- **Tractor-operated pigeon pea transplanter with adjustable row to row and plant to plant spacing:** Its field capacity and field efficiency are 0.13 ha/h and 76 %, respectively, with a wheel slip of 8%.
- **Small tractor-operated EPN applicator for sugarcane white grub management:** The field capacity of this equipment is 0.18 ha/h.
- **Tractor-operated garlic clove dibbler for raised beds:** The field capacity, field efficiency, missing, and multiples of equipment are 0.22 ha/h, 73.6%, 3.5 and 8.5%, respectively, at 0.56 m/s forward speed.
- **Four-row self-propelled onion weeder for closely spaced onion crops:** The field capacity, field efficiency and weeding efficiency of the machine are 0.06 ha/h, 85% and 93%, respectively, at 0.34 m/s forward speed.
- **Ergonomically designed girdling tool with safety attachment for Litchi:** The modified hammer drill girdling tool, weighing 2 kg, classified as light to moderately heavy, has a hand-arm vibration of 0.78 to 0.91 m/s^2.
- **Motorised caterpillar killing hand spraying tool for litchi tree:** It has a better efficiency over injections with a syringe system in eliminating caterpillars after 7 days of spraying.
- **Tractor-operated garlic harvester on a raised bed:** The machine has 0.21 ha/h effective field capacity and 72% field efficiency in 100 mm row to row and plant to plant spacing at 0.54 m/s forward speed and 60-80 mm working depth.
- **Tractor-operated integrated harvesting-cum-conveying machine:** The average cut height, effective field capacity, and field efficiency of the machine are 66-80 mm, 0.19 ha/h and 78%, respectively at 0.42m/s forward speed.
- **Front-mounted pigeon pea harvester for raised bed, flatbed and ridge-furrow system:** The field capacity, field efficiency and cutting efficiency of the machine ranged between 0.3-0.55 ha/h, 78-89% and 87-98%, respectively.
- **Tractor-operated drainage trencher:** The machine is suitable for making trenches of 0.15-

0.16 m width and 1–1.1 m depth and laying sub-surface pipes. The field capacity and field efficiency of the machine is 250-365 m/h and 81%, respectively, at 0.08 m/s, with a cost saving for excavation to the tune of 40-50%.

- **Test-set up for evaluating secondary filters used in micro-irrigation systems:** The maximum flow rate through the system is 19 m^3/h with an average filtration efficiency of 31% at 70 kPa for TSS loads < 1000 ppm.
- **Mole drainage technology for waterlogged vertisols for soybean crops under broad bed furrow:** It has an enhanced soybean yield by 67-70% over the temporary waterlogged vertisols, costing less than pipe drainage system.
- **Spectral vegetation indices for water stress assessment in wheat crop:** The normalised difference water index, water index, and moisture stress index provide an indirect estimation of water stress for the prediction of wheat grain yield.
- **Mobile App for roof water harvesting:** It calculates the optimum tank size and analyses the reliability and water-saving efficiency of the rainwater harvesting system. It also estimates various para-meters, such as inflow volume, storage, release, spillage (tank overflow), deficit, cumulative deficit, cumulative demand, and deficit rate.
- **Solar assisted ePrime mover (SAePM) for agricultural operation:** It has a field efficiency of 82%, weeding efficiency of 70%, field capacity of 0.06 ha/h and power requirement for weeder of 550 W.
- **Retrofitting of CNG kit in CI engine tractor:** The CNG consumption in the field condition without load and for rotavator (1676 mm size) operation has been recorded as 3.07 and 4.2 kg/h, respectively
- **Portable downdraft gasifier:** It is used for low tar producer gas production without active use of water for scrubbing. The final tar in the gas is in the range of 28-56 mg/Nm^3, having a heating value of 5.1 – 6.9 MJ/m^3. The composition of producer gas is CO: 16-24%, H_2:18-20%, CH_4: 2.7-6.7% and O_2: 3.4-7.7%.
- **Extraction of lipids from the microalgae:** Seven litres of n-hexane are used to extract lipid from 0.5 kg microalgae biomass with average lipid content of 17%, while 65% of the solvent can be recovered.
- **Biocrude from pigeon pea stalk:** It was generated by distillation in the temperature range of 120 to 180 °C, 180 to 240 °C and 240 to 360 °C, contained phenols (from second fraction), tetradecane & hexadecane (from third fraction), etc.
- **Motor-powered baby corn dehusker:** This machine aims to reduce the drudgery and improve the hygiene of dehusking delicate baby corn: The machine has 100% slitting efficiency, 92% dehusking efficiency, and 100% desilking efficiency.
- **Post-harvest treatment machine:** The shelf life of fruits and vegetables can be enhanced using this machine having capacity of 1-1.2 t/h. The provision for varying the operating speed of the machine permits variations in the treatment time of the commodities.
- **Machine vision-based automatic fruit grader:** This is used for efficient classification of fruits based on their weight and appearance: Besides the classification of the fruits, the machine also offers the possibility of washing with water (hot/cold).
- **Peeling machine for medicinal tuber crops:** The machine operated by 3 hp motor with a capacity of 18-20 kg/h, has a peeling efficiency of 92% for *Safed musli* and 55% for *Shatavari*.
- **Ergonomically designed pedal-operated de-bunching equipment for medicinal tuber crops:** The capacity of the machine is 11.28 kg/h, with a de-bunching efficiency of 88%.
- **On-farm heat pump dryer for curing tobacco leaves:** The energy-efficient eco-friendly dryer is noiseless and yields uniformly coloured dried tobacco leaves in less time than conventional curing barns.
- **Pilot plant for the extraction of dietary fibre from soybean and chickpea hulls:** The unit has a capacity of 10 kg of hulls per batch and 80% extraction efficiency.

Value-added products and processes

- **Chemometrics protocol for distinguishing infected and non-infected potatoes:** Early detection of potato spoilage is possible by analysing the volatile organic compounds (VOC) released by the potatoes during storage.
- **Chitosan coating for grain storage materials:** The coating considerably increased both the mechanical and barrier properties.

Chitosan-coated jute bags are recommended as the best packaging material for sorghum and pearl millets.

Technology transfer, training and capacity building

- A total of 16 technologies were commercialised to 15 manufacturers through licensing. Six MoUs were signed with different organisations.
- 4689 Research prototypes were supplied.
- 51 machines were tested and generated ₹ 78.20 lakhs as Revenue.
- 57 Training programs organized/ workshops/ seminars/interaction meets/review meeting.
- One patent was granted, Seven Patents were filed, one copyright registered, and two copyrights were filed.
- Four PhDs were awarded to students, and 3 scientists received their PhD degrees
- Staff participation in different training programs: 24

Awards and Recognitions

- Awards: Sardar Patel Outstanding ICAR Institution Award 2020 and, ISAE awards and others

Publication

- Research papers, publications: during this year 85 research papers, 30 book and book chapters, 8 technical bulletins, 30 popular articles, 5 extension bulletins and 4 technical reports were published.

Events

Some of the events organised during the year include 26th Meeting of ICAR Regional Committee, Brain Storming Session on Strategies for *Atmanirbhar Bharat* in Agricultural Mechanization, Automation in Agricultural Engineering, Annual Workshops of AICRPs, RAC Meeting, World Water Day Celebration, International Women's Day Celebration, International Yoga Day, National Conference in Hindi, National Webinar on 'Resilience and Cope-up Strategies in Pandemic through Agricultural Engineering Interventions: Women's Perspective', National webinars on "Smart grain management technology for long-term safe storage", "Roadmap on Agricultural Mechanization in state of Madhya Pradesh", "Eat Smart Right from Start", "Early diagnosis of crop issues using drone-based hyper-spectral imaging", "Post-Harvest Quality Control and Value Chain in Horticulture", "Agriculture and Environment: the Citizen Face", Krishi Yantra Nirmata Diwas, etc.

INTRODUCTION

ICAR-Central Institute of Agricultural Engineering (CIAE), Bhopal, the only premier institute for agricultural engineering, is devoted to promoting agricultural mechanisation with the aim of enhancing agricultural productivity, reducing drudgery in agricultural sectors, generation and management of energy in agricultural systems, resource conservation, minimise post-harvest loss, value addition, by-product utilisation, human resource development, and creation of employment opportunities in the rural sector.

Established on February 15 1976, the Institute has recently completed its 45 years of glorious journey. The institutional activities are organised through five divisions (Agricultural Mechanisation, Agricultural Produce Processing, Agricultural Energy and Power, Irrigation and Drainage, and Technology Transfer), four AICRP coordinating centres (Farm Implements & Machinery; Increased Utilization of Animal Energy with Enhanced System Efficiency, Energy in Agriculture and Agro-based Industries and Ergonomics & safety in Agriculture), two centres (Center of Excellence on Soybean Processing and Utilisation, and Krishi Vigyan Kendra-KVK) and a regional centre at Coimbatore. The Regional Center at Coimbatore addresses the engineering intervention needs of the southern states of the country. While, pan-India needs are catered through different AICRPs and CRPs, linked with ICAR-CIAE. The Center of Excellence on Soybean Processing and Utilisation promotes soybean utilisation through its research, development, and training activities. The institute KVK serves to demonstrate the technologies for broader adoption by the farmers in general and of the Bhopal district in particular. The Institute is also involved in postgraduate teaching and research activities to train the young minds for the development of scientific knowledge.

The mandates of the Institute are

- Research on mechanisation in production, post-harvest processing, and energy management in agriculture
- Human resource development and capacity building through outreach, training and teaching programs, commercialisation and utilisation of agricultural engineering technologies

The Institute is located at 77°25' E longitude, and 23°16' N latitude at an elevation of 498.7 m above mean sea level. It has 93.85 ha of land used for research, office and residential purposes. The major water sources are six open wells, eight tube wells, and five farm ponds. All the water sources are connected through an underground irrigation grid to irrigate 21 ha of cropped area and 15 ha of orchards. The Institute also has a meteorological observatory, well-furnished hostel and guest house facilities for 80 guests. The Research Workshop provides the facilities for fabrication of research prototypes and the Prototype Production Centre for multiplication; the Computer-Aided Design cell develops computer-aided models and drawings of research prototypes; Agricultural Knowledge Management Unit assists in database creation and conducting online examinations; Instrumentation Cell supports instrumentation in various research projects. The institute library is equipped with a computerised cataloging facility, with around 21000 books and bound journals and an extensive collection of CD-ROMs (full form) on journals in agricultural engineering and related disciplines. The library subscribes to about 60 Indian and foreign journals and provides e-subscription of some journals. The infrastructure created at the Institute caters to various research & development and technology transfer activities. Besides this, the Institute also hosts lead centres of two Consortia Research Platforms, namely, 'Engineering Interventions in Precision Farming and Micro Irrigation Systems' and 'Energy from Agriculture. The Institute provides international leadership in the agricultural mechanisation domain through its major activities in the programmes like UN-ESCAP CSAM, AARDO, SAARC, etc. In addition to the regular research and developmental activities, the Institute caters to the need for testing and certification of agricultural production and processing machinery manufactured by industries through its Bhopal and Coimbatore centres.

Over the years, the Institute has developed many successful technologies. Training and skill enrichment programs for different types of stalk holders, *viz.*, farmers, manufacturers, upcoming entrepreneurs, extension functionaries, teachers, students, etc., of either gender have been continuing for a long time. Display and demonstrations of technologies on appropriate platforms are also persisting. To augment the technology dissemination, production, and supply of successful prototypes has become a successful model. The continuous efforts made by this Institute for society have brought accolades to the Institute through the conferment of the prestigious Sardar Patel Outstanding ICAR Institution Award for the year 2020. Higher education in agricultural engineering as an outreach centre of ICAR-IARI, New Delhi, is being continued. The details of personal and finance during the year 2021 is shown below.

Staff position as on (31-12-2021)

Posts	Sanctioned	In position	Vacant
RMP	1	1	0
Head KVK	1	1	0
Scientific	89	73	16
Technical	144	65	79
Administrative	67	39	28
Skilled support staff	42	23	19
Total	344	202	142

Budget (2021-22)

	Allocation (₹ in lakh)	Expenditure (₹ in lakh)
CIAE	6929.56	6896.47
AICRP on FIM	1501.36	1501.36
AICRP on EAAI	1157.38	1157.31
AICRP on UAE	580.18	580.16
AICRP on ESA	469.99	469.94
CRP on FMPF & MIS	148.81	148.79
CRP on EA	108.52	108.33

*Expenditure till 31-03-2022

ORGANOGRAM

Department of Agriculture Research and Education,
Ministry of Agriculture and Farmer's Welfare

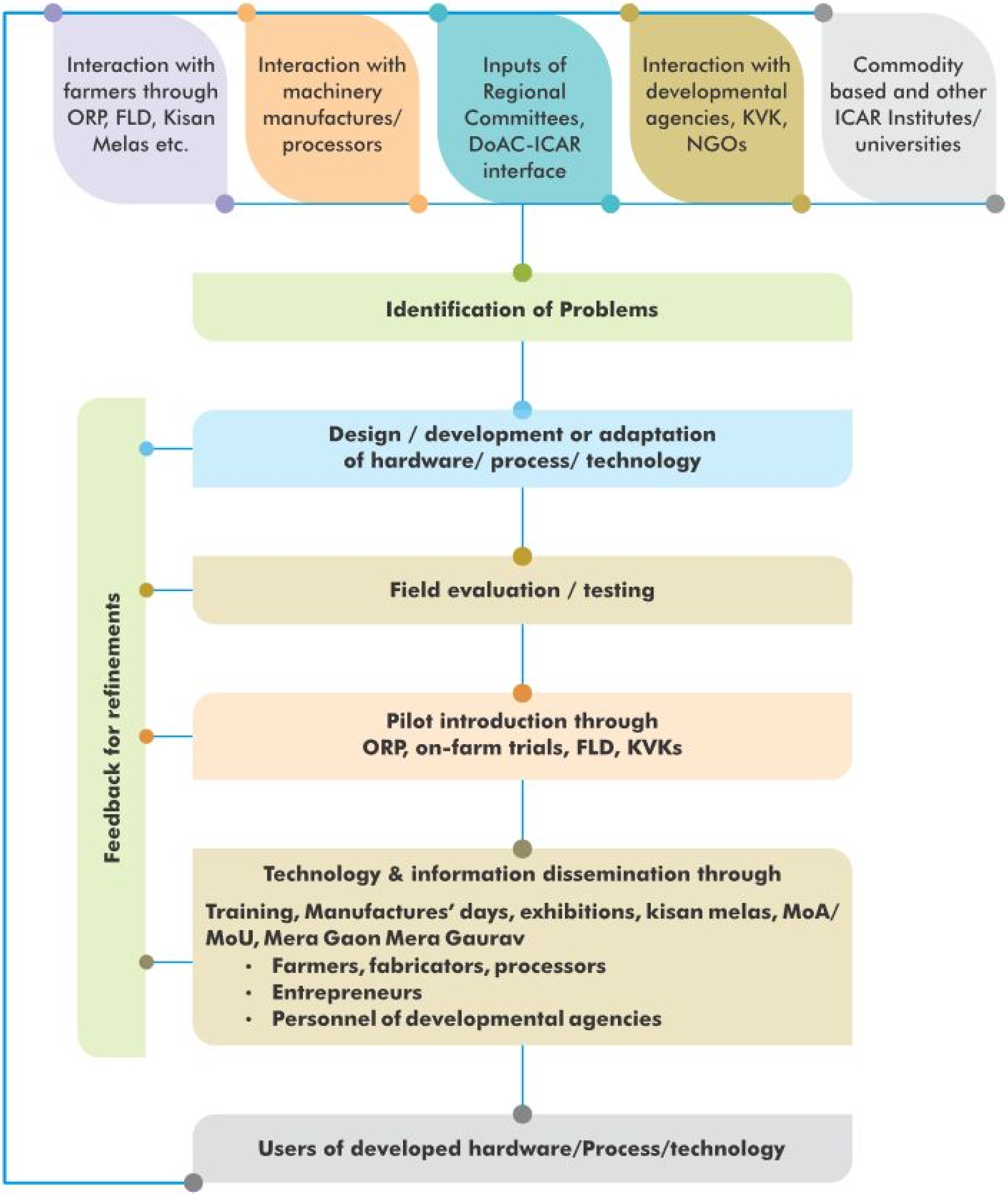
Indian Council of Agriculture Research

Subject Matter Division (Engg.)

ICAR-Central Institute of Agriculture Engineering

- Research Advisory Committee
- Prioritization Monitoring & Evaluation Cell
- Post Graduation Cell
- Divisions
  - Agriculture Mechanization
  - Agriculture Produce Processing
  - Agriculture Energy & Power
  - Irrigation & Drainage Engg.
  - Technology Transfer
- Central Facilities
  - Research Workshop
  - Prototype Production
  - Instrumentation Cell
  - Farm Production & Field Research Management
  - International Training Centre
  - Machinery Testing Centre
  - Guest House/Hostel
  - AKMU
  - CAD Cell
  - ATIC
  - Estate Management
  - Audio Visual Unit
  - Dispensary
  - Library
- Institute Management Committee
- Institute Research Committee
- Administration, Audit & Accounts
- Co-ordinating Cells of AICRPs/CRPs
  - Farm Implements & Machinery
  - Energy in Agriculture & Agro-industries
  - Harness Animal Energy System
  - Ergonomics & Safety in Agriculture
  - Farm Mechanization and Precision Farming
  - Energy from Agriculture
- Research & Extension Centres
  - Krishi Vigyan Kendra
  - Centre of Excellence for Soybean Processing & Utilization
  - Regional Centre, Coimbatore

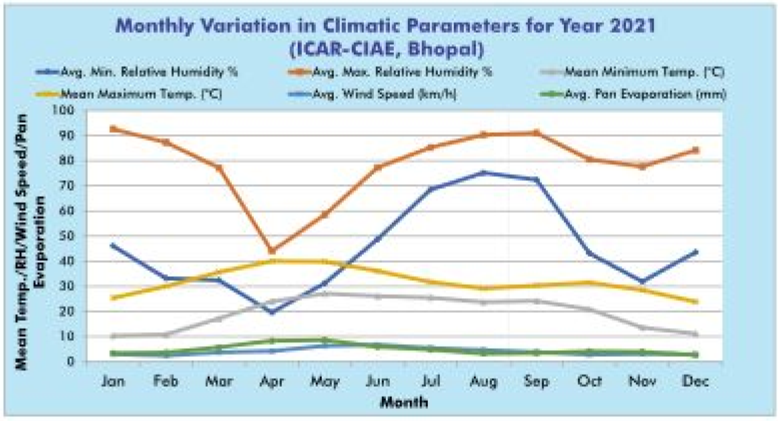
TECHNOLOGY DEVELOPMENT PROCESS OF ICAR-CIAE

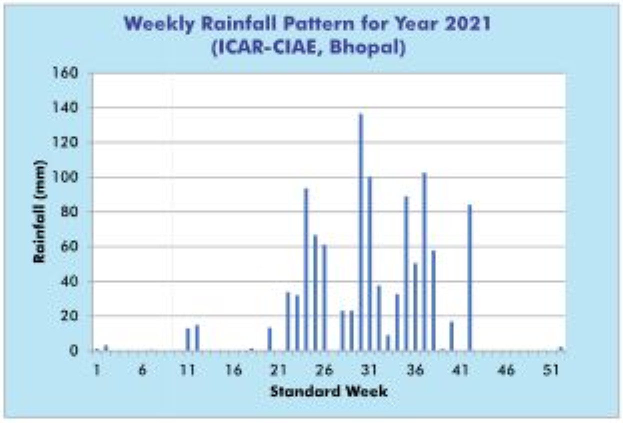


METEOROLOGICAL OBSERVATIONS

Agro-meteorological observatory of the Institute is located at 77°25' E longitude, and 23°16' N latitude at an elevation of 498.7 m above mean sea level. Rainfall, minimum and maximum temperatures, relative humidity (RH), pan evaporation and wind speed are recorded on a regular basis at the observatory. Salient meteorological observations for 2021 are:

- Monsoon arrived on June 10, 2021, one week before its normal arrival course and withdrew on October 20, 2021. The year's highest rainfall (72.4 mm) was recorded on October 18, 2021. Annual rainfall of 1120 mm occurred on 64 rainy days during the year 2021.
- The maximum temperature of the year (43.2 °C) was recorded on April 29, 2021, while the minimum temperature (2 °C) was recorded on January 31, 2021. The weekly average Relative Humidity (RH) in the morning (7:20 AM) varied from 44 to 93 per cent, while in the afternoon (2:20 PM), it varied from 20 to 72 per cent.
- The highest daily average (24 h) wind velocity of 10.5 km/h was recorded on May 18, 2021, while the lowest was 1 km/h on December 16, 2021.
- The highest monthly average pan evaporation of 8.6 mm/day was recorded for May 2021, while the lowest was 2.6 mm/day for December 2021.





RESEARCH AND TECHNOLOGY

AGRICULTURAL MECHANIZATION DIVISION

Tractor-Operated Drip Lateral and Plastic Mulch Layer-Cum Planter

Plastic mulch along with drip irrigation has tremendous potential for increasing crop and water productivity and profitability. Therefore, a tractor-operated drip lateral and plastic mulch layer-cum planter has been developed to perform raised bed forming, laying drip lateral and plastic mulch, and planting in a single pass

of the tractor. The tractor's hydraulic system is used to operate the eccentric slider-crank mechanism with the help of the MR200 hydraulic motor, whereas the vacuum is created in a housing of the metering mechanism through an aspirator blower operated by tractor PTO. The seed metering plate and eccentric slider-crank mechanism are synchronized in such a way that the seed picked by the pneumatic metering plate gets dropped in the duckbill mechanism, which opens after entering into the plastic mulch. The actual field capacity and field efficiency of equipment are found to be 0.2 ha/h and 74%, respectively at a forward speed of 0.47 m/s and operational width of 1.2 m. The cost of operation is ₹1500/h. Equipment has provision to change row to row and plant to plant spacing of 0.5 m to 1 m and 0.2 m to 1 m, respectively by mechanical means. It is suitable for planting watermelon, corn, onion, lettuce, green peas, okra, beans, etc.

Tractor Drawn Precision Pneumatic Hill Drop Planter-Cum-Fertiliser Applicator for Rice-Wheat Cropping System and Pigeon Pea

Direct seeded rice (DSR) and system of crop intensification (SCI) technology can be adopted to overcome limitations of traditional sowing of hybrid seeds. Therefore, a tractor drawn precision pneumatic hill drop planter with fertiliser applicator has been

developed. The planter consists of drum type seed metering device, petrol engine operated suction fan, seed boxes, churning device, cut-off plate, spill out chamber, scrapping plate, vertical plate type metering device for fertiliser, shoe type furrow openers, chain and sprocket type power transmission system. The field capacity and field efficiency are estimated to be 0.42 ha/h and 70.36% for rice and 0.44 ha/h and 73.04% for wheat, respectively. Average depth of planting for rice and wheat are found to be 60 and 55 mm, respectively. As compared to laboratory values, the quality feed index and precision index has been found 3.3% less and 11.22% more, respectively for rice and 2.6% less and 27.9% more, respectively for wheat. The seed rate has been observed as 14.20 and 23.14 kg/ha for rice and wheat, respectively. The cost of planting operation and payback period has been estimated as ₹990/ha and 7.7 years, and ₹960/ha and 7.35 year for rice and wheat, respectively.

The planter has been evaluated for pigeon pea in the flat bed, raised bed, and ridge and furrow conditions. The performance of the machine is tabulated below.

Field condition	Field efficiency (%)	Field capacity (ha/h)	Cost of machine (₹)	Operating cost/ha (₹/ha)
Flat bed	87	0.70	92500	1152
Raised bed	84	0.50	1,12,500	2216
Ridge & furrow	85	0.40	1,12,500	3287

Manual two-row, bullock-drawn three-row, and tractor-drawn eight-row pneumatic seed drills with similar metering mechanisms have also been developed and tested. The results of the developed machines are tabulated below.




Machine	Field efficiency (%)	Field capacity (ha/h)	Cost of machine (₹)	Operating cost (₹/ha)
Manual (Two row)	70	0.09	20,000	2222
Bullock drawn (Three row)	80	0.13	6,00,00	2500
Pneumatic seed drill (Eight row tractor drawn)	80	0.50	8,00,00	700

Garlic Clove Dibbler for Raised Beds

Garlic cloves are planted in rows at 30-40 mm depth and 150 mm spacing. One hectare of garlic cloves planting requires about 65-85 man-days. Due to uneven seeding and a higher seed rate, farmers prefer manual sowing. For precise dibbling on broad beds, a tractor-drawn eight-row garlic clove dibbler has been developed. The machine can dibble garlic at 150 mm seed-to-seed and row-to-row spacing. The machine has

a main frame, dibbling unit, metering unit, stationary cups, seed box, cams and guides, levelling roller, depth control wheel, power transmission unit, bed shaper, and three-point hitching system. Garlic cloves are picked from the seed box and dropped into the chain-cup metering unit's cups. The dibbling unit receives garlic cloves from metering unit cups and buries them at the proper depth. The dibbling unit has a front-mounted levelling roller. The machine has been tested for dibbling garlic cloves in eight rows on 150-mm-high, 1200-mm-wide beds with 300-mm-wide furrows at 40 mm depth. At 2 km/h forward speed, the field capacity, efficiency, missing, and multiples of the unit are 0.22 ha/h and 73.6%, 3.5 and 8.5%, respectively.

Self-Propelled Weeder for Onion

Slow-growing, shallow-rooted onions can lose yield to weeds. Besides, narrow, upright leaves are not weed-resistant. Unrestricted growth of weeds in onions can reduce yield by 36-48 percent. Due to close spacing,

onion weeding is tedious, expensive, and time-consuming. Therefore, a four-row self-propelled onion weeder has been developed based on the vertical rotary weeding principle for closely spaced onion crops. Spring tines are used in each weeding unit. Each tine has a 100 mm hub. All four units are mounted on a 150 mm-spaced main frame and powered by a 1.12 kW gasoline engine. Chain sprockets and a 1:20 worm gearbox operate weeding units. On either side of the main frame, two 400 mm pneumatic wheels are provided.

Ground wheels are powered by chain and sprocket. At 1.2 km/h and 85% field efficiency, the machine can harvest onions at 0.06 ha/h, with an efficiency of 91-93%. For 200 mm row spacing, the percentages of uprooted, damaged, and dead plants are 1.07%, 1.6%, and 0.97%, respectively. The self-propelled onion weeder costs about ₹3,570/ha versus ₹9,500/ha for manual weeding. This weeder can save 96% of the time and 62% of the cost. Line transplanting of onion seedlings is recommended for the best performance of the weeder.

Girdling Tool with Safety Attachment for Lichi

A battery powered hand drill was modified as girdling tool for Litchi. The modified tool has a safety

attachment. After preliminary testing at ICAR-CIAE, Bhopal, it has been tested at ICAR-NRC Litchi, Muzaffarpur, Bihar. The girdling width and depth obtained on litchi trees are 2-3 mm and 3-4 mm, which meet the requirement. Ergonomic and vibration studies imply a light to a moderately heavy heart rate of 87-107 bpm on operating the girdling tool weighing about 2 kg. The modified hammer drill girdling tool's hand-arm vibration is 0.78 to 0.91 m/s^2, which is under the 8-h limit

Motorized Spraying Tool for Caterpillar Killing in Litchi Tree

A motorized spraying tool has been developed to eradicate the bark-eating caterpillars in litchi trees. An extended nozzle kills caterpillars in litchi tree boreholes. This hand sprayer has a motor, battery, and spraying pump. The motorised caterpillar killing hand spraying tool has been tested on litchi trees at NRC Litchi, Muzaffarpur, Bihar. The efficacy of the spraying tool has been evaluated by counting the number of dead caterpillars in tree holes after 7 days of spraying. In tree holes, all the caterpillars are found to be eliminated, implying a better efficiency of this tool over injections with a syringe system.

Garlic Harvester for Raised Beds

Harvesting is one of the most laborious and time-consuming operations in garlic production, which requires about 50-60 man-days/ha. Garlic is harvested by pulling the plants by hands in a bending posture. To overcome this problem, a tractor-operated garlic harvester has been developed for harvesting garlic crops grown on raised beds (150 mm height, 1200 mm top width, and 300 mm furrow width). The machine consists of a mainframe, circular disc, blade, conveying

unit, gearbox, belt-pulley drive, and depth control wheel. Two cutting discs are provided to cut the furrow slice vertically. Ten triangular blades are attached in front of the conveying unit to loosen the soil and easy penetration. The machine has chain type conveying mechanism, which is rotated by belt and pulleys driven by tractor PTO. The garlic harvester has been evaluated in the crop sown at 100 mm row to row and plant to plant spacing at 1.93 km/h forward speed and a working depth of 60-80 mm. The effective field capacity of the machine is 0.21 ha/h at a field efficiency of 72%. The harvesting efficiency and bulb damage during the operation are 97% and <0.5%, respectively.

Bunch Field Crop Harvester

The harvesting of bunch crops such as soybean, black gram, green gram, etc. is still carried out manually to reduce the harvesting losses to a minimum, which requires 18-25 man-days/ha. These crops are, however, susceptible to higher losses, when harvested using conventional reapers due to higher interaction between machines and plants. On the other hand, the use of combine harvesters has limitations of availability for small fields. The shattering losses also increase exponentially at late harvesting. Therefore, a tractor-operated integrated harvesting-cum-conveying machine with a 2.12 m cutter bar width has been developed. It is a modified from vertical conveyor reaper with an integrated conveying system for conveying cut crops to a collection box attached behind. The developed machine has been evaluated for the harvesting of soybean, black gram, and green gram. The average cut height, effective field capacity, and field

efficiency of the machine are 66-80 mm, 0.19 ha/h and 78%, respectively at 1.5 km/h forward speed. The harvesting losses vary between 1.5-2.9%. The unit cost of operation is ₹710/h. The Break-even point (BEP) and payback period of the machine are 84 h/year and 2.5 years, respectively.

Tractor Front-Mounted Hydraulically Operated Two-Row Pigeon Pea Harvester

Harvesting of pigeon pea is conventionally done by manual picking, especially for vegetable purposes or the pods are harvested by cutting the plants by sickle. This practice often requires 12-18 man-days for harvesting one hectare of land, making it an expensive,

time-consuming, and labour-intensive activity. A front-mounted, hydraulically driven two-row pigeon pea harvester has been developed and tested. The performance of the machine is presented in the following table.

Field condition	Cutting efficiency (%)	Field efficiency (%)	Field capacity (ha/h)	Cost of machine (₹)	Operating cost (₹/ha)
Flat bed	98	80	0.55	6,00,00	930
Raised bed	87	78	0.40	6,00,00	2130
Ridge & furrow	89	89	0.30	6,00,00	1520

Website and Android App for Farm Machinery Package

Agricultural implements and machines enable the farmers to employ the power judiciously for production purposes. Awareness and availability of agricultural implements and machinery are big issues in rural areas. More than 40% of farmer households have problems accessing information on modern farming technology. Mechanization in agriculture, particularly horticultural crops enhances the production and productivity of crops through timeliness, better management of inputs, and improved quality of work. Day by day farm machinery is becoming more challenging and costlier to maintain. Therefore, the trend of purchasing farm machinery by farmer is moving towards a package of machinery owned by a group of people. The selection of a farm

machinery package based on requirements is not only difficult but also an intelligent decision that is influenced by factors other than cost and economics. The present study is an attempt to solve the problem of the selection of a package of horticultural machinery with economic considerations, machine details, and manufacturers. The web-based packages of major horticultural crops in the form of a database and android based mobile-app have been developed.

Equipment/ Technology Under development

Tractor Front-Mounted Hydraulic Pruner

Pruning involves removing plant branches, buds, or roots. Pruning fruit trees increases annual fruit production. Insufficient pruning of fruit bearing trees might result in undersized, poorly coloured, low-sugar fruit. Pruning influences fruit quality and next year's fruiting potential. Commercial orchardists use power-operated compact equipment to speed up and improve pruning. Hand-operated equipment is time-consuming and tiring, so a tractor-mounted hydraulic pruner was designed. Tool carrier, frame, pulley, bush, adopter, etc. have been fabricated. Circular saw blades, double-acting hydraulic cylinders, hydraulic motors, control

valves, hose pipes, radiator, etc. comprised the pruning system. The cylinder's rod end is attached to the hood's base frame and the bore end to the telescoping frame. The hydraulic cylinder allows the telescopic square frame pipe to adjust to plant height. A four-bar linkage mechanism frees horizontally attached square pipe according to double-acting hydraulic cylinder's reach and retract mode. Hydraulic motors rotate circular saw blades for tree pruning. A hydraulic motor with a belt and pulley arrangement rotates each blade. The pruning system had eight circular saw blades with 72 and 56 teeth. Hydraulic motors, belt and pulley, and a hydraulic power bank rotate circular saw blades. The blade assembly is lowered and raised using five double-acting hydraulic cylinders.

Spray Droplet Deposition Characteristics of Unmanned Aerial Vehicle

Only a small amount of pesticides' active ingredient can be deposited on target crops using conventional spraying. A ground-based sprayer must spray 450 L/ha. About 55% of the spray volume lands on the target, while 45% lands on the ground or drifted away with the wind. UAV (Unmanned aerial vehicle) in pesticide spraying has gained a lot of attention from government agencies, agricultural machinery companies, and agricultural research institutions in recent years. An UAV simulation platform consisting of two units of circular hollow pipe, 15-m-long hollow pipes for monorail trolley rails, has been developed. Each side of the track has a C-channel vertical column. Six vertical columns and side truss assembly (4.5 m apart) are provided to reduce rail track bending. The rail track trolley's BLDC motor controls forward and reverse motion. The UAV

simulation unit includes four propellers with BLDC motors, ESCs, nozzles, receivers, remote controls, and liquid tanks. SMPS supplies AC power to the BLDC motor.

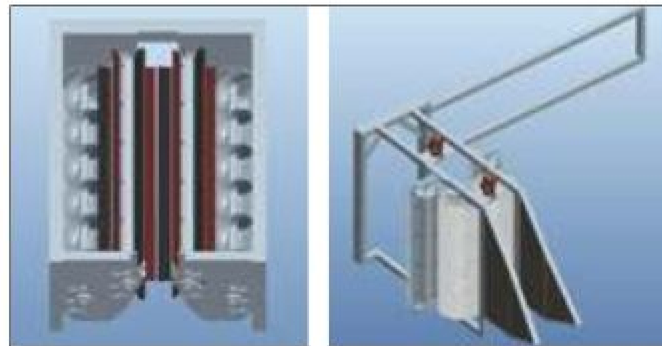
Measurement Setup for Assessing Pneumatic Plucking Force of Orange

Orchard growers in developing countries are adopting robotic fruit harvesting due to labour shortages. Most fruit harvesting in India is done manually, and technology adoption is slow. A tractor-mounted, PTO-powered vacuum-based semi-automatic type fruit-picking system has been developed for orange-picking. The machine operates on a 5-kW centrifugal vacuum blower, where vacuum pressure is controlled by a shutoff valve placed between the flexible pipe and centrifugal blower. The system has an image processing system and MATLAB IDE that measure fruits' area, perimeter, length, width, and RGB value. A program in Arduino UNO IDE has been written to measure the

fruit's initial weight and pulling force until it detaches from the peduncle. Vacuum pulling requires maximum, minimum, and average pulling forces of 31.03, 1.59, and 11.21 N, respectively, while manual twisting with pulling requires 24.89, 0.99, and 6.68 N. During vacuum picking, almost 20% of the fruit's peduncle and some inside materials are detached, regardless of maturity.

Brush Type Cotton Harvester for Indian Conditions

Manual cotton picking is laborious and expensive. Commercially available and imported cotton harvesters could not succeed in India due to a lack of suitable varieties, defoliants, and multiple picking. So, a low-cost tractor-operated brush-type cotton harvester for Indian conditions is being developed. Cylindrical brushes make up the roller brush cotton stripper head. Nylon brush threads pick cotton from open balls, leaving unopened balls alone. Counter-rotating vertical cylindrical drums with brushes detach cotton from nylon threads by



(a) Roller brush type (b) Brush and rubber bat type

combing. Cotton from combing brushes is suctioned and conveyed by pneumatic conveyor. Brush and rubber bat type cotton stripper heads have two counter-rotating rollers with three brush strips and three rubber bats to strip cotton from open cotton bolls. Screw augers on either side of rollers transport cotton balls to the head's discharge end.

Conservation Agriculture and Control Traffic in Wheat-Soybean Cropping System

A field experiment was conducted in 2020-21 to determine the effect of control traffic and residue level on wheat-soybean crop productivity in vertisols. The experiment had two cultivation systems, traffic control (CT) and random traffic (RT), as main treatments and six residue levels as sub-plot treatments (H1-30% Residue, H2-60% Residue, H3-100% Residue, H4-Residue Incorporation, H5-Residue Burn, and H6-Strategic weeding and tillage). The recommended wheat cultivation practices for Rabi 2020-21 and Kharif 2021 were adopted. Adjusting the tractor's track width allowed seven-row wheat sowing. Controlled traffic was also used for fertilising, chemical application, and weeding. Tractor-drawn seed drill's field capacity and slip were 0.47 ha/h and 5.6% for controlled traffic and 0.67 ha/h and 7.4% for random traffic. Soil compaction level within 0-200 mm depth was found to be 1011-

1163 kPa for traffic control (CT) and 1163-1417 kPa for random traffic (RT), whereas, before wheat sowing, soil bulk density was 1429 (CT) and 1488 kg/m^3 (RT). After soybean harvest, at 0-200 mm depth, soil compaction was 270-1419 kPa (CT) and 1108-1998 kPa (RT). The soil bulk density was found to be 1429 kg/m^3 and 01488 kg/m^3 (RT) before wheat showing. The average wheat yield was 5.85 t/ha for controlled traffic fields and 5.65 t/ha for random traffic. Controlled and random traffic yields were 1 t/ha and 0.8 t/ha for soybeans (RVS-2001-4), respectively.

Image-Based Hand-held Device for Disease Identification in Soybean

Lack of infrastructure makes identifying crop diseases difficult in many parts of India. Deep learning has paved the way for automatic disease detection using open-source software. This project identified soybean diseases using GoogleNet, AlexNet, and ResNet models. A total of 3,472 soybean leaves has been collected from the fields for training, validation, and testing of the Deep learning (DL) models. GoogleNet, AlexNet, and ResNet have overall classification accuracies of 88%, 89%, and 88%, respectively with RGB images. Google net had the highest precision (0.78), while AlexNet had the highest F1 score (0.80) and sensitivity (0.85). A handheld device and mobile app have been developed at ICAR-CIAE, Bhopal for disease identification in the field. Raspberry pi 3 B+, 127 mm display, 5 MP camera, battery, frame, and accessories make up the handheld device. The mobile app's test results on 50 images have shown classification accuracy of 30-40, 90-100, 90-100, 30-40, and 80-90 percent for Circuspora, disease-free leaf, Frogeye leaf spot (FLS), Soybean mosaic virus (SMV), and Yellow Mosaic Virus (YMV), respectively. The handheld device has been developed and mobile app development is in progress.

Hand-held device for disease identification in soybean

Mobile app GUI

AGRO-PRODUCE PROCESSING DIVISION

Post-Harvest Treatment Machine for Fruits and Vegetables

Due to improper material handling practices, a sizeable amount of post-harvest losses occurs in fruits and vegetables. A lot of scientific treatment protocols exist that the fruits and vegetables can be subjected to before they are stored for market or sent for transportation. These treatments can increase the shelf-life and the table life of the products. An ergonomically designed single operator machine of 4.4 m in length, 1 m in width, and 1.6 m in height made of SS-304; and produces noise far less than 80 dB has been designed and developed. The machine has a three-phase electric power requirement at a peak capacity of less than 2.5 unit/h. The machine's capacity depends on the product being handled (e.g., for capsicum 1.2 t/h, for apple 1 t/h) at a 5 m/min linear belt speed. There is a provision to vary the operating speed of the machine; this permits

the required variations in the treatment time of the commodity as per the established scientific protocols. Water forms the medium of treatment operations contained in a tank with a working capacity of 500 L, and water jets are operating at varying pressure to wash the commodities as well. Treated and washed commodities travel on a roller conveyor where rotation/rolling and linear motion ensure adequate exposure to pulsed light treatment before being collected at the discharge chute.

Automatic Fruit Classifier

Machine vision-based sorting systems for fruit enables efficient sorting, uniformity in commodity quality, the increased market value of the product, and contribution to food safety, security, and traceability issues in pack houses. "Automatic Fruit Grader" is a touch-screen-based user-friendly machine wherein washing, weight-grading, and colour-sorting can be carried out in a

single go. This machine can segregate fruits based on appearance as "accepts" and "rejects" and based on three weight categories "small," "medium," and "large." Besides the classification of the fruits, the machine also offers possibilities of washing with water (hot/cold). Agricultural commodities with sphericity ranging from 0.7 to 1.0- and 90-mm diameter can be classified by this machine. There is a touch screen for man-machine interaction and a combination of sensors, actuators, and microcontrollers for the automation of the process. The machine is an in-house fabrication of the Institute, made of SS-304, thus making it robust and resilient to the operating conditions. This machine results in an overall drudgery reduction of about 82.8% and saves time up to 56% over similar manual operations. The machine's capacity is 1680 fruits/hour (oranges: 250 kg/h, pomegranate: 350 kg/h) with a weight (±5 g) and colour-based grading at an accuracy of 91% and 97%, respectively.

Peeling Machine for Medicinal Tuber Crops

Peeling of medicinal root crops such as *Safed musli* and *Shatavari* has been a critical bottleneck in the post-harvest processing of medicinal root crops. Manual peeling involves drudgery and is a tedious task. A machine has been developed which is suitable for peeling medicinal tuber crops. The machine has the provision of a feeding hopper, a washing system, an abrasive peeling mechanism, and a discharge spout. The peeling operation has been accompanied by a water spray system for the removal of peel during the operation to increase peeling efficiency. The machine has been fabricated in stainless (SS 304) material. The machine operates with a 3 kW motor and 3 cylinder recirculatory pump set and variable frequency drive. Installation of a recirculatory water system reduces water consumption and effluent disposal issues. The developed machine has been tested for *Safed musli* and

Shatavari roots. The peeling efficiency is about 92% for *Safed musli* and 55% for *Shatavari*. The capacity of the machine is about 15-20 kg/h, which is thirty times higher than manual operation.

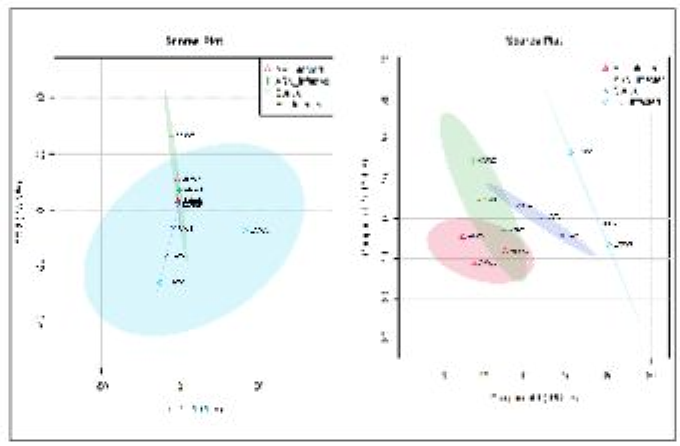
Pedal-Operated De-Bunching Tool for Medicinal Tuber Crops

Medicinal tuber plants like *Safed musli* and *Shatavari* have bunches of roots with their apex ends attached. The first step in the post-harvest treatment and processing of these roots is to separate them. Currently, the roots are separated by manually cutting them with a knife which is tedious and risky. Pedal-operated de-bunching equipment has been designed with ergonomic considerations. It consists of a working table mounted with a spring-operated C-shaped blade, a

tank for raw material, and a discharge spout. All the machine components coming in contact with the raw materials are fabricated with food grade SS304 stainless steel for ensuring hygiene. The capacity of pedal-operated de-bunching equipment was recorded as 11.28 kg/h, with a debunching efficiency of 88%.

Chemometrics Protocol for Distinguishing Infected and Non-Infected Potatoes

Early detection of the spoilage of potatoes during bulk storage is very critical to control the losses. Volatile Organic Compounds (VOCs) generated during storage of potatoes inoculated with *Erwinia carotovora*, *Aspergillus niger*, and *Aspergillus flavous* have been mapped through Solid phase microextraction (SPME)-Gas chromatogrphy-Mass Spectroscopy (GC-MS) method. Principal component analysis (PCA) has been used for the dimensional reduction and classification of the VOC data obtained from different infection species and experimental conditions. A classification protocol has been developed for distinguishing infected and uninfected samples of potatoes. The VOC data can be



reduced through this classification process from 124 compounds to 2-3 major principal components. The hierarchical cluster analysis (HCA) illustrates the similarity among the VOC compounds and possible discrimination among the sample groups. The clustering process considers every storage condition as an independent cluster and then selects and combines these clusters among themselves. Further, the technique of Partial Least-Squares Discriminant Analysis (PLS-DA) has been employed for classifying the groups based on discriminant features of VOC data. Classification among storage conditions (at 25 °C, 8 °C, and 4 °C), which are not classified through PCA, can be further classified using PLS-DA techniques through the discrimination between variables.

Equipment/ Technologies under Development

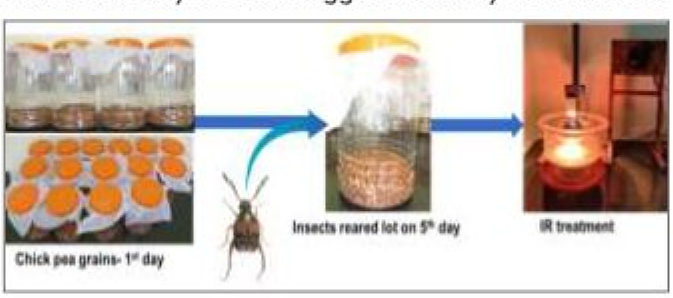
Grader for Medicinal Tuber Crops

The roots of medicinal crops like *Safed musli* and *Shatavari* are of varying sizes. In the existing practices, fresh roots crops are not graded and the roots are manually peeled mostly. The varying size results in uneven drying and affects the performance of the mechanized peeling system. Therefore, power-driven

grader equipment is being developed. It consists of rotating rollers with chain and pinion arrangements, a feeder, and three discharge outlets. The roots, when fed, pass through the gaps between the rotating rollers, grading them into three different sizes without any damage. The machine is operated by a 3.72 kW motor with a reduction gear arrangement. The testing and fine-tuning of the machine are in progress.

Infrared Heat-Radiation-Based Disinfestation of Chickpea Grains Infested with *Callosobruchus maculatus*

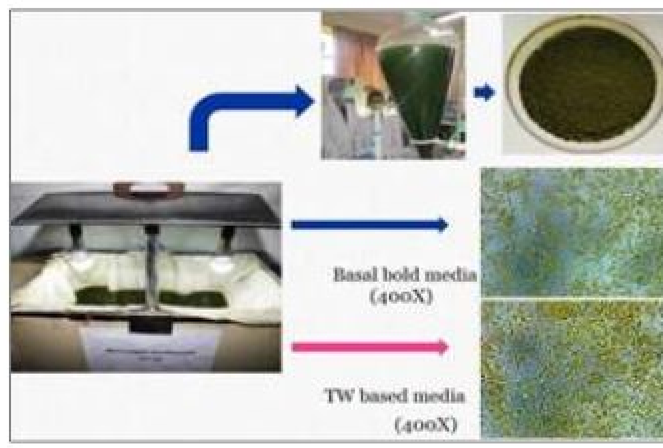
The Infra-Red (IR) disinfestation treatment parameters have been optimized during experiments on *Callosobruchus maculatus*-infested chickpea. Chickpea grains conditioned to 10% (wb) moisture level have been artificially inoculated with *Callosobruchus maculatus* adults. On allowing the adults to lay eggs over the grains, the samples are then exposed to infrared treatments with different heaters to grain spacing (45, 70, 95, 120, and 145 mm), and treatment times (30, 60, 90, and 120 s). One hundred percent insect mortality and zero egg hatchability in the case of



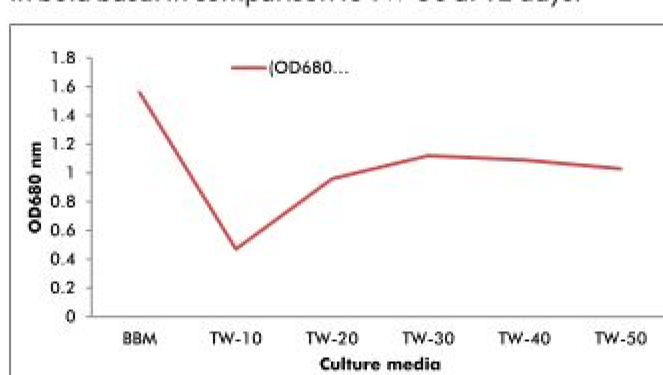
C. *maculatus* with minimum changes in the selected quality attributes in terms of weight loss (0.31%), grain surface temperature (81.1 °C), protein content (20.3%), protein dispersibility index (0.57), hardness (438 N) and crushing strength (192 N-mm) can be achieved at 45 mm of heater to grain spacing and 60 s of treatment time conditions.

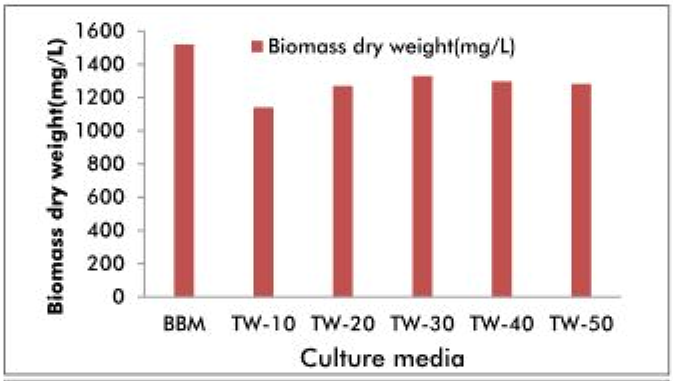
Plant By-products Based Culture Media for Micro-algae Production

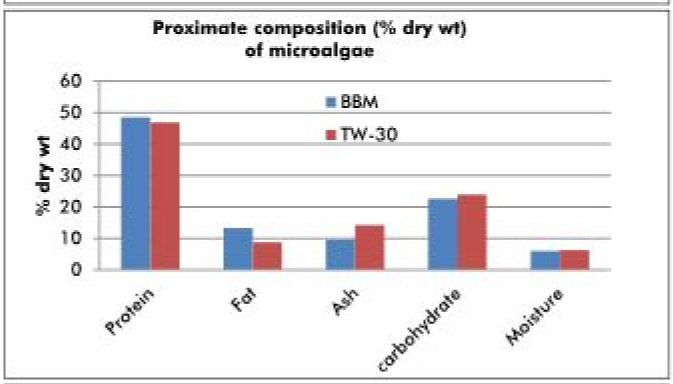
The organic compounds contained in the tofu whey (TW) can be degraded into macronutrients needed by autotrophic organisms, such as microalgae. TW has been utilized in the production of culture media for microalgae cultivation with intended use in the food sector. Specific microalgae strains of *Chlorella singularis* obtained from the Algal Research and Bioenergy Laboratory, Uttaranchal University, Dehradun, India are used in the investigation. A laboratory-scale setup (30 L/batch) has been developed with the provision of a light source and manual aeration for the cultivation of microalgae. The pH value of TW-based nutrient media at pH 6.5, 7.0, and 7.5 showed good results (based on yield and absorbance OD_{680} nm). A growth study (yield and absorbance OD_{680}) with different dilutions of the TW mixture has been performed. Dilution of tofu whey mixture up to 30% showed good results in terms of

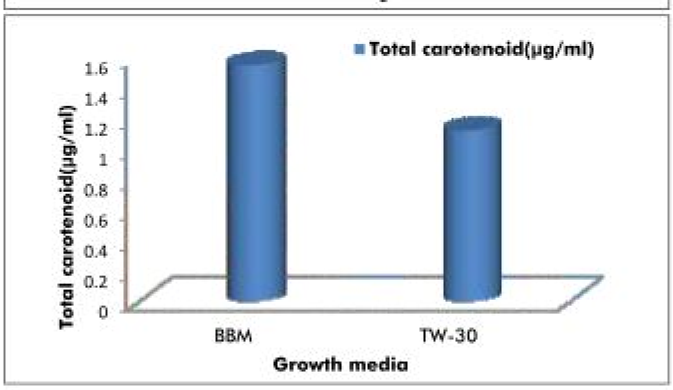


carotenoid content, protein, fat, and ash content. Diluted culture media at 30% showed comparative results with bold basal media (BBM). The findings indicated that it is a suitable medium for microalgae production. Microalgae strains grown in developed media (TW based) at the laboratory level show good growth density in comparison to bold basal media (BBM). The protein and lipid contents are slightly higher in bold basal in comparison to TW-30 at 12 days.



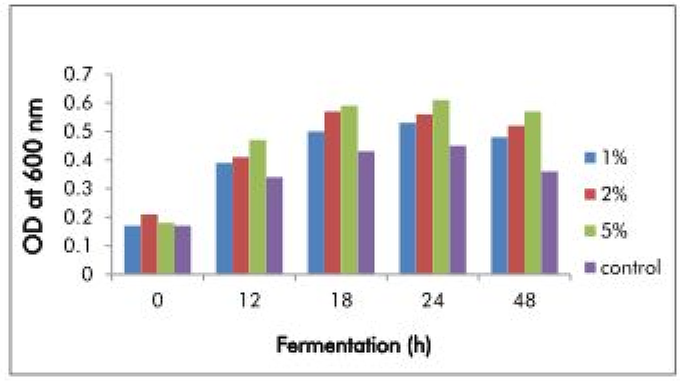






Plant By-product-Based Prebiotic Preparation for Food Applications

Prebiotics are non-digestible or/of low digestibility food ingredients that aid the host by selectively stimulating the growth of beneficial bacteria in the colon. In combination, prebiotics and beneficial bacteria can provide more health benefits than probiotics and prebiotics alone. A process protocol has been developed to produce hydrolyzed by-products based on solid mixtures from tofu whey, okara (soy by-products), pea pod, and cabbage sepals. Hydrolysed solid mixture is prepared through solid-state fermentation of sterilised fresh tofu whey, okara, and cabbage sepals, inoculated with yeast. *Lactobacillus spp* was used with hydrolysed solid mixtures for evaluation of their prebiotic characteristics. The bacterial strain used for performance as prebiotic in soymilk is *Lactobacillus spp*. The prebiotic index of the formulated mixture was also determined in reference to inulin in soymilk. The prebiotic index is found to be 1.17 (Prebiotic index, PI),



which indicates a positive effect on fermented bacterial growth. The developed hydrolyzed mixture was an effective substrate for microbial growth, which is evident from the increase in the absorbance in tofu whey-based hydrolysed mixture.

Testing of E-Nose for Real-Time Health Monitoring of Onion, Potato, and Tomato under Storage

An electronic sensing system (e-Nose) has been developed in collaboration with C-DAC Kolkata for the real-time health monitoring of the onions, potatoes, and tomatoes in storage. The system consists of eight metal oxide semiconductor sensors (MOS), equipped as an array, signal conditioning system, amplifier, Analog-to-Digital Converter, 32-bit ARM processor-based board, and other auxiliary accessories. The developed system has been tested at ICAR-CIAE, Bhopal. During test operation, the user needs to select the appropriate commodity on the touchscreen display and feed in the necessary information related to the test. After that, the system automatically activates the appropriate MOS sensors assigned for a particular crop. Furthermore, the Volatile Organic Compounds (VOC) gets sniffed from the storage unit, passes through the auxiliary heating chamber, and then through the sensor array. The respective sensor detects the VOC concentration and expresses it in numeric form. The values of the 8 sensors further generate a single index value through which the condition of the crop can be judged. The whole cycle of the measurement, computation, and result output is completed in 7 min. The system can distinguish the differences based on VOC for all three commodities as the sensor readings and index value change with respect to the storage period following the specific trend. Testing and fine-tuning of the e-nose system are in progress.

AGRICULTURAL ENERGY AND POWER DIVISION

Solar-Assisted E-Prime Mover for Agricultural Operations

Application of solar voltaic in agriculture is required for sustainable development. This also can be extended to mobile applications along with the stationary application. A solar-assisted e-prime mover (SAePM) has been developed and its field evaluation for spraying and weeding (horizontal rotor) has been conducted. The speed of operation for the horizontal rotary weeder and sprayer is 1.3 and 2.6 km/h, respectively. The field

efficiency, weeding efficiency, field capacity, and power requirement for the weeder are 82%, 70%, 0.06 ha/h, and 550 W, respectively. Similarly, the field efficiency, field capacity, and power requirement for boom sprayer are 83%, 0.52 ha/h, and 50 W, respectively. The power consumption by the prime mover varies from 932 W to 1648 W for movement in the field and 229 - 593 W for spraying and weeding operations.

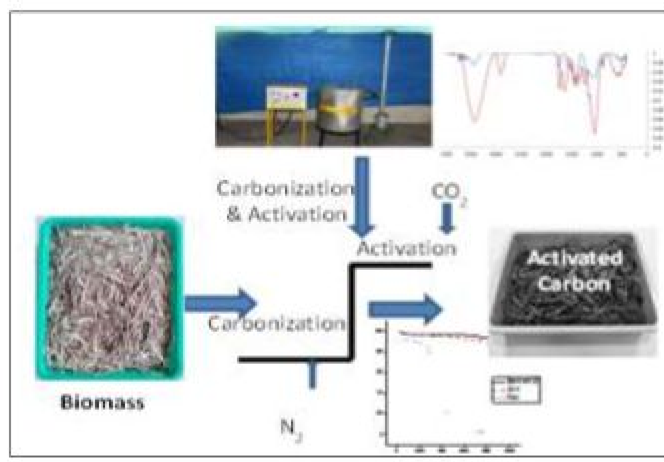
Modification of Diesel Engine Tractor for CNG

A systematic approach has been adopted to convert the CI engine of the tractor to an SI engine. A CNG-based system has been retrofitted in a three-cylinder tractor engine by redesigning engine components. The

compression ratio of the tractor engine has been modified to 10.33:1 to suit the required ignition time for CNG. Spark plugs have been suitably placed in all three heads of the tractor engine and the spark distributor is aligned in the timing gear mechanism of the tractor with a modified flange. Carburetion of the air-CNG mixture has been ensured with suitable arrangements. The operation of the tractor with 100% CNG has been successfully carried out. The CNG consumption in the field condition without load has been recorded as 3.07 kg/h. The CNG consumption during rotavator (1676 mm size) operation has been observed as 4.2 kg/h.

Single Step Activation of Pigeon Pea Stalk Char for Higher Adsorption Capacity

Agro-residue-based char can be upgraded to activated char by different activation methods. A single-step process of activation has been evaluated. In the initial step, the pigeon pea sample is carbonized at 450 °C for 45 min during which volatile vapour is allowed to



escape. Thereafter, the temperature is increased to a predefined experimental activation temperature. At activation temperature, carbon-di oxide is fed to the reactor chamber for activation. The temperature and activation time for carbonization and activation is controlled using a profile PID controller. The activated carbon has an iodine value ranging from 449 to 751 mg/g with a recovery percentage varying from 7 to 25%. Both activation temperature and time influenced the quality of activated carbon significantly. The maximum iodine value is obtained at 900 °C temperatures and held for 60 min. A second-order polynomial response equation was used to correlate the dependent and independent variables. There are good agreements between the experimental and predicted values of recovery % and iodine value with R^2 of 0.96 and 0.94, respectively.

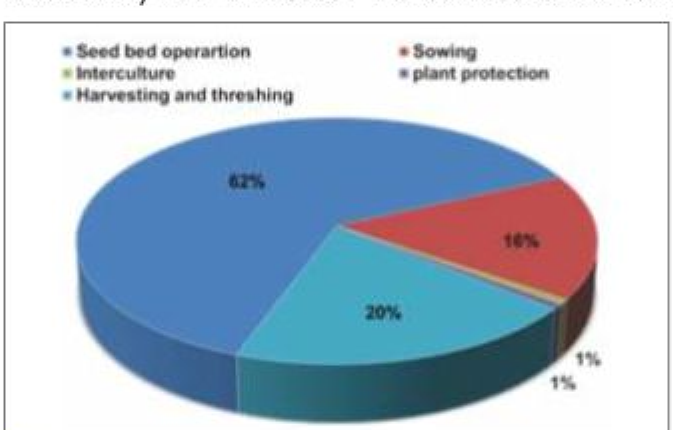
Process Protocol for Extraction of Lipid from Microalgae for Biofuel Production

Microalgae are important organisms for the production of value-added products and lipids in the field of renewable energy. A facility to extract lipid from microalgae biomass has been developed in the institute. This system can handle biomass up to 3 kg and a solvent of 15-20 L. Trials have been conducted to extract lipids from the microalgae biomass with five extraction cycles for each operation. The lipid from 0.5 kg micro-algae biomass has been extracted using seven litre hexane at 70 °C for 2 h. Separation of lipids from the solvents and recovery of solvents have been carried out at 70 °C through a rotary evaporator, with a solvent recovery of

65%. The average lipid content of the microalgae harvested using hydrolysate media is about 17%.

Energy Inflow and Outflow Analysis for Production of Soybean Crop

Energy input in the soybean crop is increasing due to the increasing demand for fertilizers and chemicals. The energy input scenario has been assessed for central India. Data collected from 120 farmers from the eleven villages of the Vindhya plateau based on the random selection method have been analysed. Farmers under marginal (<1 ha), small (1-2 ha), and others (>2 ha) have been considered to calculate the energy requirement for soybean crop production. The total energy inputs and outputs have been depicted in the figure. Fertilizer is the most energy-intensive source followed by fuel and seed. The contribution of fuel



energy in the energy matrix has been maximum in seedbed preparation (62%) followed by harvesting, threshing (20%), and sowing operation (16%). Energy inputs and grain productivity are increased from marginal to other categories of farmers.

Inbuilt Tar Cracking in Portable Gasifier

A portable downdraft gasifier has been developed for the production of low tar producer gas without the active use of water for scrubbing. Tar is reduced by using char-based nickel catalysts in this gasifier. The main reactor is conical throat type for easy downward movement of feed material. A grate is provided below the throat to support the fuel bed as well as to segregate ash. A stirrer is used for the intermittent stirring of feed material as well as to prevent clinker formation. The catalyst bed is placed at the periphery of the oxidation zone and immediately after the reduction zone. Thus, the producer gas generated from the oxidation and reduction zone passes immediately through the hot catalyst bed where cracking of tar takes place. The gasifier can accommodate 60 kg fuel pellets and a suitable facility is provided for intermittent fuel loading for continuous operation. The final range of tar in the gas is observed in the range of 28-56 mg/Nm^3 having a heating value of 5.1 – 6.9 MJ/m^3. The fuel consumption in the developed gasifier is observed as 10-12 kg/h. The composition of producer gas is CO: 16-24%, H_2:18-20%, CH_4: 2.7-6.7%, and O_2: 3.4-7.7%.

Technology under Development

Process to Produce Insulation Blocks from Paddy Straw

In an attempt to utilize paddy straw (PS) for value-added products, experiments are being conducted to prepare insulation blocks of different sizes from ground paddy straw (raw form as well as torrefied). Paddy straw is chopped, torrefied at 220 and 250 °C for 20 and 30 minutes, respectively, and ground. Torrefied paddy straw is then screened with 7 mesh size for removal of dust and other unwanted impurities. Screened treated PS (8-15mm) is mixed with different combinations of synthetic and natural binders followed by cold pressing in a mould at the pressure range of 3.47 -17.36 kPa. Similarly, untreated PS after grinding and screening is combined with a suitable proportion of binders and water to form an insulation block. A composite block made with dimensions of 128 × 150 × 18 mm using

paddy straw (untreated) in combination with a synthetic binder (5% v/v) and water (5% v/v), cold pressed and dried in a solar dryer at 60 °C for 2 days has a bulk density of 578 kg/m^3.

Multiutility E-Vehicle for Light Agricultural Operations

The use of batteries can be a better option for reducing energy inputs in agriculture production and have a stand-alone energy solution for different agricultural operations if a suitable charging facility is created. The aim is to develop a battery-powered multi-utility e-vehicle (MUeV) with a smart charging system for light agricultural operations (spraying, sowing, and harvesting). Three attachments, namely spraying, sowing, and harvesting is being developed. The power required for the vehicle is supplied by a DC motor and Li-P batteries. The king pin inclination of 5° and camber

angle of 3° have been maintained for proper steering of wheels. Considering the lighter work to be done in the field, the traction wheel having 165 mm rim width and 406 mm rim diameter has been selected. The torque requirement for cutting, conveying, and propelling has been calculated as per the standard procedure. The dimension of the workstation has been maintained as per ergonomics designs suiting most of the drivers.

Screw Pyrolyzer for Continuous Production of Biochar

A screw pyrolyzer is under development for the conversion of biomass to biochar. The effective length of the pyrolyzer is 1200 mm. The material for the construction of the reactor is stainless steel. A screw is used for material transport inside the reactor. The shaft is rotated by a geared motor and speed is controlled by a variable frequency drive. The screw speed can be varied from 2 to 30 rpm which gives solid residence time varying from 20 s to 5 min. The heat supplement system consists of a downdraft gasifier, blower, and gas burners. Fuel consumption rate using pellets of 6 mm diameter has been noted as 7.5 kg/h. The temperature

of 478 °C has been attained after 55 minutes of operation from an ambient of 32 °C and then maintained at about 460 °C. The feeding rate can be varied from 9 to 28 kg/h. Biochar recovery varied between 29 to 44%.

IRRIGATION AND DRAINAGE ENGINEERING DIVISION

Drainage Technology for Waterlogged Vertisols

The high initial cost of sub-surface drainage technology is one of the main constraints in its adoption on large-scale in vertisols. A study has been carried out to investigate the effect of broad bed furrow (BBF) with mole drainage on the productivity of soybean crops (sensitive to waterlogging) during five consecutive *Kharif* seasons at the institute farm during 2015-2020.

The BBFs have been formed at the time of sowing using BBF-cum-seeder machine. Mole drains of 85 mm size have been formed at 500 mm depth and 4 m spacing using tractor operated mole plough (40-60 kN drawbar pull). The adoption of surface drainage (BBF of triangular shape having 200 mm depth, 400 mm top width, and 1.5 m spacing) technology increased soybean yield by 27-30% in temporary waterlogged vertisols over the conventional practice of cultivation, whereas the adoption of BBF with mole drainage system enhanced soybean yields by 67-70% over the temporary waterlogged vertisols in the region receiving normal and heavy rainfalls (monsoon rainfall >1070 mm). The payback period of BBF with mole drainage is less than 2 years. BBF with mole drainage has been observed to be a cheaper and more viable alternative to a costly pipe drainage system.

Tractor-Operated Drainage Trencher for Laying Sub-Surface Pipes

Trenching operation for laying the sub-surface drainage pipes is tedious and labour-intensive work. In India, more than 6.73 Mha area is salt affected and nearly 75 Mha area is under vertisols, which have low hydraulic conductivity problem that leads to temporary waterlogging. It is, therefore, necessary to develop an indigenous machine to excavate the trench, lay drainage pipes, and achieve the desired grade for removal of excess water and salts from the root zone of crop, especially in *Kharif* season. A tractor-operated drainage trencher using a three-point hitch system has been developed and evaluated at the research farm of ICAR-CIAE Bhopal for laying sub-surface pipes. The developed trencher can make trenches up to a depth of 1–1.1 m with a width of 150–160 mm. The operating speed of the trencher was found to be 0.083 m/s. The machine can dig trenches with a width of 150-160 mm

at a rate of 250-365 m/h and lay a drainage pipe subsequently at the desired grade. The cost of the developed trencher is approximately ₹3,00,000/- and the cost of operation is about ₹1,300/h. The field efficiency of the machine is 81%. The developed unit can save the cost of the excavation to the tune of 40-50% over presently used excavators, and will increase the annual use of the tractor.

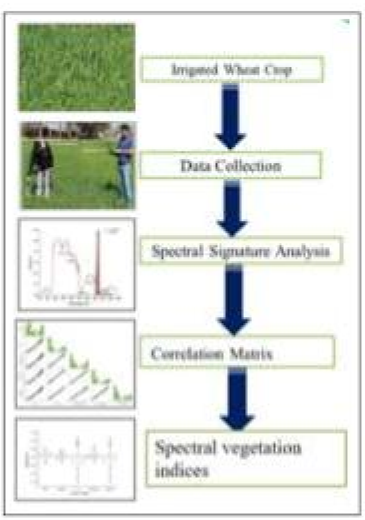
Test Set-Up for Micro-irrigation Filters

The filtration system is considered as "heart of the micro-irrigation" system and a faulty filtration system can lead to emitter clogging. A test set-up has been developed for testing secondary filters used in micro-irrigation systems. It is equipped with a volumetric flow

measuring device, ultrasonic flow meter, and pressure monitoring devices besides devices for electrical energy metering. The calibration of pressure gauges and flow meters has been carried out to obtain true values. The system is equipped with a back washing mechanism for cleaning and flushing chocked filters. A sampling point has been provided to collect the samples of filtered water during the operation of the system. A screen filter of 100-micron size having a capacity of 20 m^3/h flow rate has been tested under different TSS loads of 2000, 1500, 1250, 1000, and 750 ppm. The maximum flow rate through the system has been observed as 19 m^3/h by an ultrasonic flow meter. The screen filter is cleaned manually when the head loss across the filter reaches 70 kPa. The time required for chocking of screen filter increases with a decrease in TSS load in the water. The average filtration efficiency of the screen filter for TSS loads of < 1000 ppm has been observed as 31% at 70 kPa.

Spectral Vegetation Indices for Water Stress Assessment in Wheat Crop

It is important to detect water stress before it causes permanent and irreversible damage to the plant attributes. Conventional methods of water stress measurement are laborious, time-consuming, point-based, and not suitable for automation in precision irrigation. The spectral reflectance technique has been used to estimate the water stress of wheat crops using a hand-held spectro-radiometer one week before the critical growth stages. The normalized difference water index (NDWI), water index (WI), and moisture stress index (MSI) have been calculated which gives an indirect estimation of water stress. The values of NDWI for wheat crops varied from 0.06 to 0.18 under sprinkler irrigation and from 0.04 to 0.12 under flood irrigation, respectively. The maximum value of NDWI has been observed at the flowering stage for both irrigation treatments. The value of MSI for sprinkler irrigated crops at 100% ETc was minimum (0.28-0.35) whereas maximum (0.77) in the flood irrigation at 25% ETc level. Further, these indices calculated at different growth stages were used to predict wheat grain yield. The R^2 value for yield prediction in wheat crops using MSI at different growth stages have been maximum (0.78) followed by NDWI (0.65) and WI among the different treatments. Therefore, MSI can be effectively used to correlate grain yield and water stress.

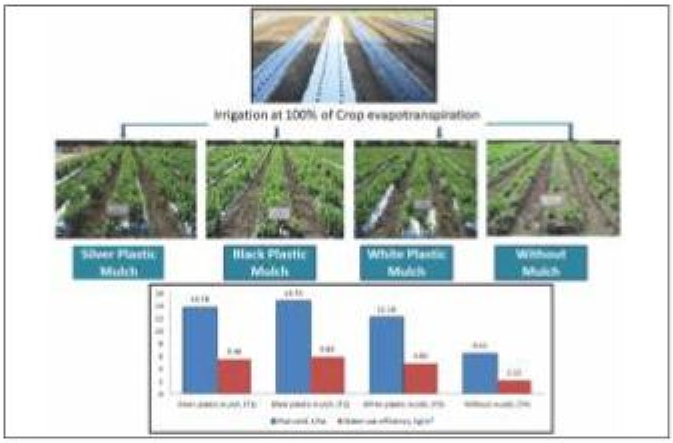


Water Balance Simulation Model for Roof Water Harvesting (Mobile App)

Rooftop rainwater harvesting (RWH) is an effective strategy to meet the increasing demand of fresh water in water-scarce regions. The information about the reliability and water-saving efficiency of the RWH system and the optimum tank size is needed for the proper designing of an RWH system for a household. Therefore, a mobile application titled "Water Balance Simulation Model for Roof Water Harvesting" has been developed to simulate the performance of RWH systems under different climatic regions. An Android-based mobile application has been developed using Java programming language. The app considers daily rainfall, losses due to leakage/spillage, roof area, and daily water demand as input parameters. The inputs can be entered manually on-screen and through a text file. It calculates the optimum tank size and analyses the reliability and water-saving efficiency of the rainwater harvesting system. It also estimates various parameters such as inflow volume, storage, release, spillage (tank overflow), deficit, cumulative deficit, cumulative demand, and deficit rate. The output can be obtained both on-screen as well as in text files. The developed app will be helpful for decision makers to give recommendations for the design of roof water harvesting systems for water saving and water security.

Pea Cultivation under Different Coloured Mulches and Drip Irrigation

The performance of Pea (*Pisum sativum L.*) was evaluated under different colour plastic mulches and drip irrigation. A two-year field experiment was conducted during *Rabi* season with four treatments (*i.e.*, silver plastic mulch, black plastic mulch, white plastic mulch, without or no mulch) and five replications in randomized block design. Irrigation was applied through drip irrigation using a two litre per hour emitter and standard fertilization practices are followed. The results showed that colour of mulching had a significant

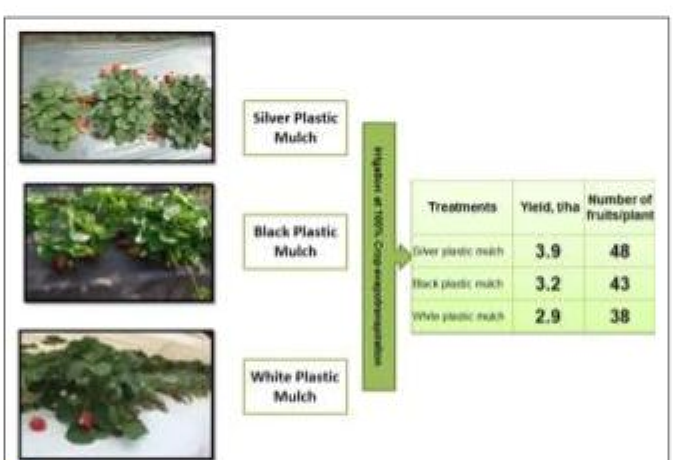


effect on growth and yield attributing parameters of green peas. Among different mulching treatments, silver plastic mulch resulted in the maximum plant height and pod length.

The highest yield and water use efficiency were recorded under black colour mulch (14.75 t/ha and 5.84 kg/m^3) followed by silver and white colour plastic mulch. The lowest value was found under treatment without mulch. The mulching leads to better plant growth by changing the microclimate by modifying soil moisture and temperature, which leads to a greater photosynthetic rate and consequently better plant growth and yield. Therefore, black colour mulch is recommended for pea cultivation in Central India.

Strawberry Cultivation under Plastic Mulches in Sub-Tropical Climate

The adaptability, sustainability and economic feasibility of strawberry crop in subtropical climates of Bhopal were evaluated under different mulches (silver, black white coloured mulch) and microirrigation (drip). The pooled data over two years (2019-2021) showed significantly higher plant height and number of leaves per plant under black mulch. However, number of fruits per plant (48 numbers) and production (3.9 t/ha) were maximum under sliver colour mulch, though at par with black colour mulch. Overall, yield per plant and water productivity were higher in silver colour much, thus recommended in Central India.



Technologies under development

Mole Plough for Undulating Field Conditions in Vertisols

Tractor mounted mole plough works satisfactorily only on levelled field surfaces. Once local surface irregularities become significant, its performance becomes poor. A long beam floating mole plough in

which the complete beam runs clear of the soil allows the mole channel to be graded independently of the average surface level without the need for sophisticated grading equipment. This will help in improving the grade control for mole drain under undulating field conditions. The soil samples of the experimental plot have been analysed for clay percent, bulk density, plastic limit and electrical conductivity, which are recorded as 46.1%, 1.39 g/cm^3 for 0-0.15 m depth, and 1570 kg/m^3 (0.15-0.30 m depth), 22.3% and 0.4 dS/m, respectively. Computer-aided design of long beam floating mole plough is prepared and fabrication of mole plough is in progress.

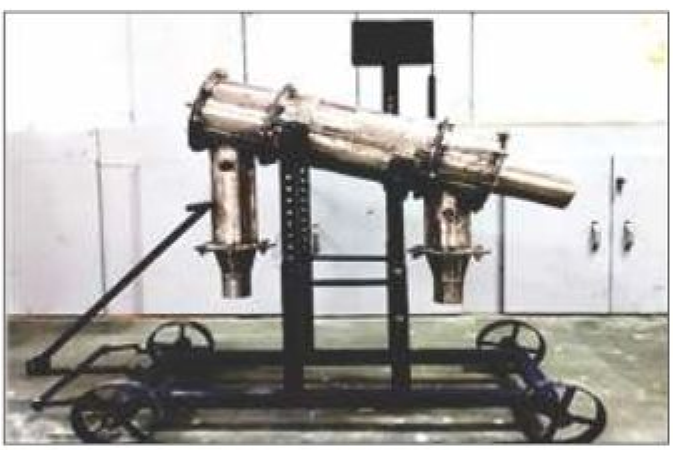
Solar Powered Floating Pump for Small Farms

A floating pump is a pump that can float in ponds, lakes, or any other water surface. It is portable and can be moved from one place to other as per needs. A solar-powered floating axial flow pump for small farms has been developed at ICAR-CIAE, Bhopal for farmers having land areas up to 0.4 ha. It has been developed to lift the water surface (up to 3 m depth) targeting ponds, rivers, canals, *etc.* The system floats on the water surface avoiding pump installation and it is portable in nature. It has a DC motor of size 250-watt capacity, attached with an axial flow pump, and operates on solar power. It consisted of two solar panels each with a 170 W rating. It is fitted with a remote control switch to operate it from an approximate distance of 30 m without

going close to the pond or other surface water sources. The developed pump has been tested in the laboratory and in the pond. The discharge of the pump is observed at around 2.5 m^3/h or 0.69 X $10^{-3} m^3/s$ at 3 m head. The pump is being tested under different solar radiations, head capacities, and impeller sizes.

Self Cleaning Filter for Micro-irrigation System

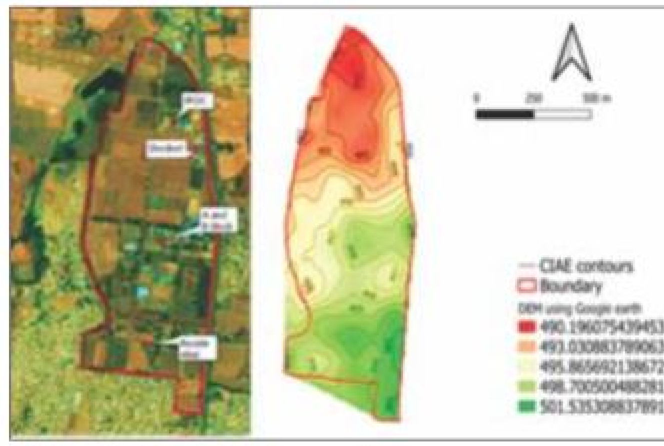
A filter is a very important part of any micro-irrigation system. Periodic service and maintenance of filters are required to ensure a continuous trouble-free operation of the system. An automatic self cleaning filter with a simple cleaning mechanism is being developed at the



institute for the micro irrigation system. A controller has been developed to monitor the filter during its operation through its pressure transmitters installed at the inlet and the outlet of the filter. The controller has been programmed to detect the choking stage as per the BIS norm (70 kPa) and act accordingly to clean it without human interventions. The controller flushes out the dirty materials from the filter after cleaning is performed. The filter is being tested with different TSS loads. It has been operated with a 1.5 kW centrifugal pump having a maximum flow rate of $5.5 \times 10^{-3} m^3/s$.

ICAR-CIAE Drainage Plan for Storm Rainfall

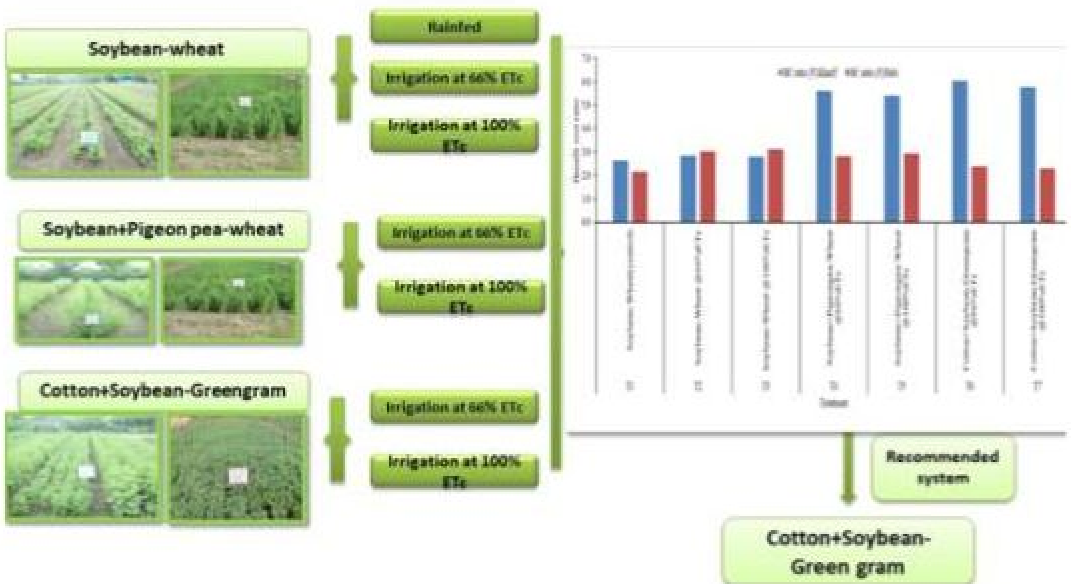
A poorly maintained drainage system would cause flooding and damage to the agricultural land and the irrigation network. Excess water on farms may result in the leaching of essential minerals and the crops failure, especially in *Kharif* season. A reconnaissance survey was conducted both for the institute campus and farm area to ascertain the condition of the existing drainage system. A digital elevation model was prepared at one meter interval to represent the terrain relief of the campus and farm area of the institute. The elevation difference for the entire institute campus varied from



502 to 491 m and it varied from 496 m to 491 for the longest drain path (730 m) in the institute farm with a slope of 0.6%. Furthermore, a suitable drainage plan for the institute campus was prepared through the construction of new structures/repair and maintenance of existing structures for site-specific drainage problems at the institute.

On-farm Water Management Practices for Enhancing Crop and Water Productivity

An experimental trial has been planned to evaluate the better practices for advocating farmers in the future for improving their livelihood with the following cropping systems, soybean-wheat (Rain fed), soybean-wheat (Irrigation at 66% ETc), soybean-wheat (Irrigation at 100% ETc), soybean+pigeon pea-wheat (Irrigation at 66% ETc), soybean+pigeon pea-wheat (Irrigation at 100% ETc), cotton+soybean-greengram (Irrigation at 66% ETc), cotton+soybean-greengram (Irrigation at 100% Etc). During *Kharif* season an intercropping combination of cotton+soybean and pigeonpea+ soybean performed superior to the sole cropping system. During *Kharif*, treatment (cotton+soybean) irrigated at 66% of ETc produced significantly higher equivalent grain yield (5.37 t/ha) and water productivity (0.47 kg/m^3) than the rest of the treatments. However, it has been found at par with treatment (cotton+soybean) irrigated at 100% of ETc. Among the treatments, no significant difference has been recorded between the yield at irrigation levels of 66% ETc and 100% ETc. Among the different field cropping systems, cotton + soybean-green gram recorded the highest equivalent yield (6.76 t/ha), system productivity (61.43 kg/ha/day), system profitability (₹440/ha/day), and benefit-cost ratio of 4.32. Minimum system productivity, system profitability, and benefit-cost ratio are found in soybean-wheat cropping systems under rainfed conditions. Thus, *Kharif* season intercropping of soybean should be done with pigeon pea and cotton to get maximum returns and at the same time minimise the risk of crop failure under the sole cropping system.



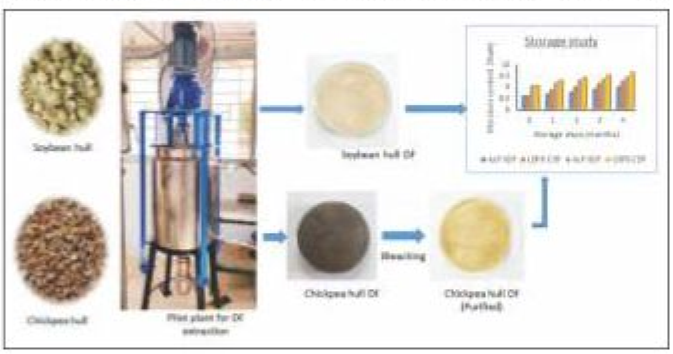
IoT-Based Smart Irrigation System

A real time irrigation scheduling system can apply irrigation in real-time and can be effectively used to water plants as and when required. An IoT-based smart irrigation system is being developed at the institute that can be monitored remotely on a real time basis. A mini solar panel, transmitter unit (ESP-8266 module) and solar charger unit have been mounted on the data acquisition systems. The power unit consists of a 6V power supply and a compatible solar panel for recharging the unit. An algorithm has been developed with soil moisture thresholds that have been programmed into a microcontroller to decide whether to irrigate or not to irrigate based on soil moisture thresholds. The controller opens the solenoid valves and thus provides water to irrigate plants till the soil moisture reaches its upper threshold value. Multiple solenoid valves are connected to the receiver unit for actuating the relay module and pump for different zones. The soil moisture content and soil temperature data are collected and stored on a Think Speak IoT platform using the ESP8266 Wi-Fi module. The data is transmitted to the Raspberry pi-based monitoring unit having a 127 mm display. The working of the system was tested in the laboratory for its proper functioning and logical operation of the solenoid valve with the irrigation pump.

CENTRE OF EXCELLENCE ON SOYBEAN PROCESSING AND UTILIZATION

Pilot Plant for Extraction of Dietary Fibre from Soybean and Chickpea Hull

Soybean hull and chickpea hull are presently discarded or used as animal feed. Dietary fibre (DF) extraction from these can generate income and reduce the waste disposal problem. A pilot plant (10 kg/batch) has been developed to extract DF from soybean and chickpea hulls. The dietary fibre extracted in the pilot plant has been characterised and compared with dietary fibres extracted in the laboratory. Dietary fibre extracted from both methods exhibited comparable properties, ensuring the compatibility of the designed pilot plant for commercial production of dietary fibre. Although the total dietary fibre (TDF) yield was slightly higher for the laboratory method (chickpea hull TDF-78.1% and soybean hull TDF-86.0%) than for the pilot plant method (chickpea hull TDF-76.5%, soybean hull TDF-80.2%), a reasonably acceptable yield was achieved from the



scaled-up method. Dietary fibre from the chickpea hull required additional purification procedures for removing its black colour resulting from certain pigments in it. Samples were further packed and sealed in LDPE and aluminium foil bags kept at ambient conditions for assessing their storage stability. Variations in moisture content, colour, water absorption index, and water solubility index during the storage period have been evaluated. All the changes are more predominant in LDPE-packed dietary fibre samples. Hence, Aluminium foil bags can be recommended as the packaging material to store the developed dietary fibres with satisfactory quality parameters maintained up to six months.

Development of Diagnostic Kit for Identification of Soy Protein in Milk and Paneer

Adulteration soymilk is generally done to boost the solids-not-fat or nitrogen content of milk, a metric that is also used for determining the price of milk. The addition of such proteins to bovine milk causes detrimental effects on raw materials in downstream processes followed in dairy industries. There is a need for a simple, sensitive, rapid, and inexpensive method to detect soymilk in dairy milk. Lateral flow analysis involving

antibody-antigen interactions is one of the easiest methods to detect soy protein in dairy milk. Preliminary studies on the antigen-antibody reaction of soy protein yielded promising results. The dairy milk gave a negative test. A testing strip was assembled from the procured material. The development of a lateral flow kit is in progress.

Assessment of the Impact of Entrepreneurship Development Training on Soybean Processing

The commercialization of technologies through training and entrepreneurship development programmes (EDP) is considered a very effective and potent tool for wealth creation, employment generation, and poverty alleviation in India through soybean processing. During a survey conducted by ICAR-CIAE, it was observed that many units were established without proper guidance. However, proper technical guidance is required to run the unit successfully. Trainees also face problems in getting financial assistance from various government agencies as most of the agencies are not aware of soybean processing and its advantages as a food. Many government agencies also need complete knowledge of soy food to implement government-funded nutrition programmes. Thus, there is a need to provide proper technical guidance to produce a quality product. Keeping this in view, the project is initiated. Information about training conducted and working units has already been collected till 2017. Since 2017, 28 training have been conducted till date. Three hundred sixteen persons took the training during this duration. Forty-three units have been established since 2017. Government and funding agencies are being contacted to create awareness and promote soybean processing and utilization. A webinar was organized on technical guidance for the establishment of a soy processing enterprise for CESPU trainees during the year 2020 – 21 on 12th May 2021.

REGIONAL CENTER, COIMBATORE

Tractor Operated Tobacco Seedling Transplanter with Spot Application of Water

Growing tobacco is labour intensive and all the operations are done by manually including transplanting. As there is no indigenous machine for transplanting tobacco seedling, a tractor operated tobacco seedling transplanter with spot application of water has been developed in collaboration with ICAR-Central Tobacco Research Institute, Rajahmundry. The unit consists of a mainframe (attachable to tractor three-point hitch arrangement) having an operator's seat, metering and seedling planting mechanism, furrow openers, tank and spot water application arrangement, and soil compaction wheel. The tobacco seedlings are dropped through the metering mechanism and placed in the furrow made by shoe-type tines. The plant-to-

plant and row-to-row spacing are adjustable from 500 to 700 mm, and 650 to 1000 mm, respectively. The dropping and watering mechanisms are actuated through a cam arrangement fitted in the transmission system. Thus, it ensures spot watering nearer to the seedling planted. Field capacity and missing percentage are 0.3 ha/h and 3% at of working speed. The quantity of water applied per plant and plant establishment are 200-250 mL and 95%, respectively. The savings in cost and labour are 65% and 85%, respectively.

Tractor-Operated Entomopathogenic Nematodes (EPN) Applicator for Sugarcane White Grub Management

Majority of the sugarcane farmers follow the spot application of EPN solution to control white grub. Manual application of EPN involves more drudgery and non-uniformity of EPN solution in sugarcane root zone. The small tractor-operated EPN applicator consists of a mainframe, standard three-point hitch, furrow opener, and tank with an agitator and water pump. The tank

consists of an agitator (baffles, operated by 12 V DC motor) and two EPN solution outlets. The pumping of EPN is performed by two 12v DC diaphragm pumps of 4 LPM capacity. This method reduces the drudgery and non-uniformity of manual EPN application. The field capacity of the applicator is 0.18 ha/h. The cost of operation and cost savings are ₹2550/ha and 47%, respectively. It has been tested at ICAR-Sugarcane Breeding Institute field and M/s. Bannari Amman Sugars research and development farms.

Tractor-Operated Raised Bed Former-Cum-Onion Set Planter for Multiplier Onion

Manual planting of onion is cumbersome and time consuming. It generally requires about 80 to 100 man-days to plant one ha of onion as 6.7 lakhs hills per ha are to be planted. Tractor operated raised bed former-cum-onion bulb planter has been developed for this purpose. The developed equipment consists of main frame, raised bed former, seed metering mechanism, seed hopper, ground wheel, furrow opener and standard three-point hitch. The main frame supported the ridger with raised bed former, leveller, standard three-point hitch and onion planting unit. It makes two raised beds with three furrows. The metering mechanism is chain

and cup feed type and driven by ground wheel. It comprises of forty-eight cups (8 rows with 6 cups per metering unit) to suit the size of onion sets. A funnel shaped box is provided at the bottom of seed onion delivery tube (to prevent spillage). This planter makes two beds of 700 mm top width where eight rows of onion can be planted simultaneously. The field capacity and field efficiency are 0.30 ha/h and 75%, respectively. The cost of operation and saving in cost are ₹2270/ha and 71%, respectively.

Tractor-Operated Pigeon Pea Transplanter

Tractor operated pigeon pea transplanter has been introduced as a new equipment by which the yield loss due to delay in date of planting can be avoided. In addition, it also ensure healthy seedlings as well as optimum plant population. The developed system consists of main and auxiliary frames with three-point hitch arrangement, a ground wheel, two chisel type furrow openers with compaction wheels, two operator's

seats, and two depth control wheels along with metering mechanism driven by ground wheel. It can be operated by 35 hp tractor with adjustable row-to-row spacing (900 mm or 1050 mm) and plant spacing. The machine weighs around 170 kg. Its field capacity and field efficiency are 0.13 ha/h and 76%, respectively with a wheel slip of 8%. The cost of operation, break-even point and payback period are ₹8000/ha, 118 h/year and 0.8 year, respectively.

Power Operated Baby Corn Dehusker

Baby corn (*Zea mays L.*) is the ear head of maize plant harvested at a young age. The ear head with husks needs to be removed before it is further processed or stored. This operation is usually done manually and involves drudgery. Hence a power-operated baby corn dehusker has been developed, which consists of a slitting section and dehusking cum desilking section. The slitting section is provided with a feed inlet pipe made of stainless steel and two pairs of swinging arm

rollers having a pair of knives, made of high-grade SS (70 mm diameter, 0.6 mm thickness, 5 mm projection length). One knife is fixed between the top set of rollers and the second knife is fixed between bottom set of rollers. To ensure a delicate handling/ dehusking of baby corn, a rubber fitting is provided over the remaining rollers and thus it provides the flexibility to bend inwards in the feed section to accommodate different contours and geometry of baby corns. The swinging arm mechanism provided to the rollers facilitates ease in the cleaning of trashes trapped in between during feeding. The husk is slitted on both sides longitudinally in the slitting section. After slitting, it passes through dehusking cum desilking section. This section comprises four rollers (300 mm in length and 75 mm in diameter) with a brush made of food-grade nylon. Husk and silks are removed in this section. Dehusked baby corns are collected at the main outlet and husks and silky portions are collected in the husk collector box beside the machine. The slitting section and dehusking cum desilking section are operated by 0.5 hp and 1.0 hp electric motors, respectively. It has a capacity of 25 kg/h. Slitting efficiency, dehusking efficiency, and desilking efficiency of this machine are 100, 92, and 100%, respectively. Thus, it reduces the drudgery and improves the hygienic dehusking of baby corn.

Heat Pump Dryer for Curing Tobacco Leaves

Curing is a process of removing moisture from the tobacco leaves and turn the leaves into a lemon-yellow

appearance for aroma of tobacco. Indigenous curing barn is coal or wood fired to produce the hot gases which cures tobacco leaf. The wood consumption is high, i.e., 4.3 kg for 1 kg of cured leaves and takes 120-140 hours (5-6 days) to complete the curing. It is a tedious process to monitor the temperature and humidity inside the indigenous barn and to feed the wood continuously by the labour to maintain temperature. The present study was on-farm trial of curing tobacco leaves which was carried out using heat pump dryer at Prakasam District, Andhra Pradesh. The freshly harvested and stringed tobacco leaves (116.5 kg) were loaded into a heat pump dryer. The set value for temperature was at par with the process temperature value inside the chamber. The moisture of leaves slowly reduced from 80% to 4 % (wb) (i.e., 20.68 kg) within 90 hours (4 days). The leaves were turned to uniform lemon-yellow colour, as desired. The quality parameters viz., chlorides, reducing sugar and nicotine of cured leaves using heat pump dryer were found to be 0.32%, 15.25% and 2.38%, Where as in indigenous barn method these values were 0.66%, 11.52% and 1.49% respectively. The heat pump dryer was found to be eco-friendly, noiseless, energy-efficient and easily maintainable.

Chitosan Coated Bags for Storage of Selected Food Grains

Post-harvest losses of food grains during storage due to infestation by storage insects are high and alarming. Chitosan is considered as generally recognized as safe (GRAS) by the US FDA in 2005. A process protocol was developed for making chitosan coated bags was 2% chitosan in 2% glacial acetic acid solution was used for dip and pad cure procedure for coating of hessian jute fabric, cloth and jute laminated PP fabric with an optimum coating parameter *viz.*, speed (1 m/min), squeezing pressure (588 kPa) and curing temperature (105 °C & 81.4 °C). The jute fabric consumed higher volume of chitosan solution (1.2 ± 0.3 L/10 m) followed by jute laminated PP (0.7 ± 0.2 L/10 m) and cotton (0.4 ± 0.1 L/10 m). It was found that the increased thickness of jute fabric, Jute laminated PP and cotton were 0.81-1.37 mm, 0.77-1.07 mm, and 0.13-0.36 mm, respectively. The tensile strength for Jute Laminated PP was found 256.93 ± 11.96 N/mm as maximum, followed by chitosan-coated jute fabric of 247 ± 36.28 N/mm. It was also observed that coating improves the gas barrier with good mechanical and lower water vapour permeability properties. Using these fabrics, storage studies were performed for sorghum and pearl millets with an artificial infestation of two weeks old grain borer and rice weevil insects for 90 days. It was found that the cumulative grain damage, weight loss, powder residue, protein total phenols, tannins and antioxidants activity are 2.51%, 1.52%, 1.56%, 9.87 ± 0.02%, 30.01 ± 0.02 mg/100 g, 28.9 ± 0.06 mg/100g and 375 ± 0.02 μg/g, respectively. The best packaging material is chitosan-coated Jute bags.

Technology under Development

Unmanned Rice Transplanter

The unmanned rice transplanter is a multi-functional gender-friendly remote-controlled system to reduce human drudgery and labour and is easy to use with an unskilled person to perform the rice transplanting operation in puddled paddy field. It consists of a remote-controlled steering system, directional and speed control system, transplanting system and emergency stop system with an auto-start option. Electronic components such as remote-control joystick, transmitter, receiver, micro-controller unit, motor drive module, actuator (wiper motor and linear actuator), relay, and ultrasonic sensors are used. Auto-start system has been developed for a ride-on-type rice transplanter using a remote controler from a distance of 500 m. The transmitter, receiver, ECU, and motor drive have been programmed to actuate the selected actuators, like the wiper motor, linear actuator to control the steering wheel, and controller for brake, accelerator and speed. The developed remote-controlled steering, accelerator-

speed and brake systems can be attached to any commercial ride-on-rice transplanter and operated remotely by an operator from a distance of 500 m. The developed remote-controlled steering, accelerator-speed, and brake systems have been evaluated in a puddled rice field and compared with manual driving. The overall variation in the lateral side is < 120 mm at a travelling speed of 0.44 m/s and a turning radius almost similar to manual driving, thus ensuring reasonable control in puddled field conditions.

Self-Propelled Track Type Vehicle for Small Farms

Most agricultural machinery are not suitable to perform in hilly areas or in loose soil as safety of operation is a concern in slopes and loose soil poses poor manoeuvrability for tractor operated machinery. Therefore, a remote controlled self propelled track type vehicle has been developed for small farms and hilly areas. The system consists of 8.9 kW petrol engine, hydraulic transmission system, track-type system and

remote-control system. The track type system consists of rubber track, load wheels, tensioners, drive wheels, rubber track tyres and chassis frame. Hydraulic transmission system consists of hydraulic tank, hydraulic pump to transmit the hydraulic power from hydraulic tank to actuator (hydraulic motor, hydraulic cylinder) through remotely-controlled electronic solenoid valves, hydraulic motor to drive the drive-wheels attached to left and right track tyre, hydraulic cylinder is used for lifting and lowering of agriculture implement. A portable remote-control system operates the developing vehicle. The controls such as direction, speed, brake and equipment function during agriculture operation will be taken care remotely from a distance of 500 m.

Tractor Operated Whole Cane Harvester

At present, harvesting of sugarcane is done manually. About 15-16 labours are required for manual harvesting of one acre of sugarcane. This labour crisis

can be solved through mechanization. The harvesting operation also involves trash removal from the green cane, and de-topping of the stalk. The stalks are then made into small bundles ready for manual loading and transporting either to mill or juice making. Continuous use of bare hands for handling and use of knife to cut the sugarcane may cause bruises on hands leading to infection. To overcome these problems, a low-cost sugarcane harvesting machine which is more efficient and having simple mechanism for cutting the sugarcane at a faster rate is attempted. It is a hydraulically operated unit mounted on tractor (II & III category three-point links), consisting of a base cutter unit, crop gathering unit, cane walker, de-topper and collection trolley. The base cutter is mounted on the main frame fitted with left side of tractor to cut the sugarcane stalk easily. Base cutter is powered by tractor PTO through gear box. Crop gathering unit is provided in the front side of de-topper and base cutter. The de-topping unit cuts sugarcane top leaf before the base cutter cuts stalk. It consists of cane leaf gathering, rotary cutting unit, height adjustment unit and hydraulic motor. A telescope vertical supporting post is provided with the help of hydraulic cylinder for height adjustment. Cane walker unit (two chain conveyers rotates in clockwise and anti-clockwise, supported by pneumatic tyre) conveys cut cane and guides them to collection trolley. It has been tested at the R&D farm of M/s. Bannari Amman Sugars ltd., Satyamangalam, Erode, TN. The cost saving is 60-70%.

Three-in-one Motorised Tool for Ablation and Harvesting of Oil Palm Fresh Fruit Bunch (FFB)

With an aim to increase the versatility of the backpack model of oil palm tool, an oil palm harvester (three in one engine operated) for ablation and harvesting of oil palm FFB up to 3 m height was developed in colloboration with ICAR-Indian Instittue of Oil palm Research, Pedavegi, Andhra Pradesh. The reciprocating holding arrangement is provided at the end of the light telescopic aluminum pole. Based on the requirement

ablation tool, chisel or the sickle can be mounted on the holding arrangement at the end of the aluminum pole. The power to the attachment is provided by means of light weight engine placed on the back of the operator.

Chilli Grader

Grading is pre-requisite for development of the modern marketing, trade and economy of any commodity. The Indian chillies are graded on the basis of colour and size, before they are marketed. Presently, grading of red chillies is done manually through visual observation, incurring more labour and time. To overcome this issue,

a power operated chilli grader has been developed which comprises of feed hopper, grading trays, outlets and power transmission components. The uniform feeding of chillies into grader is made by feed rollers. The grading unit consists of three stainless steel perforated trays arranged stepwise with collecting chambers to collect the graded chilli. It is powered by 0.5 hp electric motor. Its overall dimension is 2110 × 1270 × 1510 mm. The overall grading efficiency and capacity are 88% and 90 kg/h at crank revolution of 58 strokes per minute for Sannam variety of chilli.

Millet Popping Machine

Millet popping machine suitable for popping of sorghum, amaranthus, finger millet, kodo millet, and

other small grains including paddy, rice, and corn has been developed. It is an electrically operated continuous type recirculatory hot air system, works with the principle of hot air fluidization process. It comprises of the following components viz., heating zone, popping zone, recirculatory system, air blower along with PID temperature controller, indicators, switches and wheels, etc. It operates with 5 kW (Three phase) resulting in a capacity of 1.4-2 kg/h and 60-70% popping recovery for Sorghum and Amaranthus. The overall dimension and total weight of millet popping machine are 1000 mm × 970 mm × 580 mm, and 80 kg, respectively. It is easy for women entrepreneurs to have it as a successful business and ideal for the production of millet-based whole grain RTE niche food products.

Multiple Feed Banana Fibre Extractor

With an aim to increase the output capacity of banana fibre extraction and to make it safer in operation, Multiple feed Banana pseudo-stem fiber extractor was developed in collaboration with ICAR National Research Centre for Banana, Trichy, Tamil Nadu. The unit comprises of (i) conveyer feed belt (ii) beating roller assembly (iii) gripper holder assembly and powered by (i) 2 hp motor to operate beater roller (ii) 1 hp motor to operate conveyer belt and with suitable pairs of

proximity sensors. The banana sheaths are gripped on the holder assembly and conveyed to beater roller assembly. The directions (forward/reverse) of movement of the conveyer are controlled using electronic controllers.

Mechanised Cashew Apple Slicer

With an aim to get cashew apple slices for chips/wafer production, prototype model of mechnised cashew apple slicer was developed in colloboration with ICAR Directorate of cashew Research, Puttur, Karnataka. The mechanized cashew apple slicer comprises of a vibratory mechanism, roller conveyor, belt conveyor

with cleats, cutting zone, power transmission mechanism, and collection tray. Vibratory mechanism with feeding hopper vibrates by cam and spring arrangement. The cashew apple is conveyed to the cutting zone through a roller conveyor and belt conveyor assembly. The cutting zone with multiblade (9 blades of 165 mm diameter, operated by 0.746 kW motor) and cashew apple slices are collected. The speed of operation is controlled using a variable speed arrangement.

Cashew Fruit and Nut Separator

Currently cashew nuts are separated from the cashew fruit by hand. This is a very time consuming and a labor intensive process. In order to mechanise this operation, an effort was made to develop a motorised equipment for cashew nut separator in collaboration with ICAR Directorate of Cashew Research Puttur, Karnataka. The cashew fruit and nut separator comprises of feed inlet,

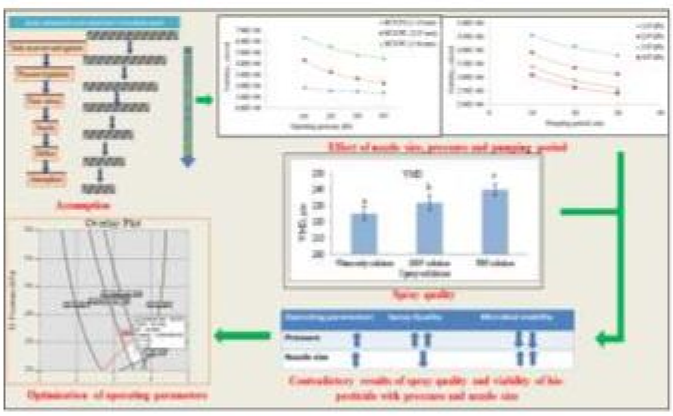
fruit conveyor, rotary modules (I&II), pomace and juice outlet, and nut outlet. The cashew fruits with nuts are fed and conveyed to rotary modules (I&II), where combined crushing and shearing enable the separation of nuts from cashew fruits. The pomace, juice, and cashew nuts are collected in separate outlets.

PG CELL

ICAR-CIAE is also running post–graduate degree program as an outreach campus of IARI, New Delhi. Four students received their PhD degree in the 2021 annual convocation of ICAR-IARI.

Studies on Spray Characteristics of Selected Nozzles with Bio-pesticides (PhD holder: Manish Kumar, Supervisor: C R Mehta)

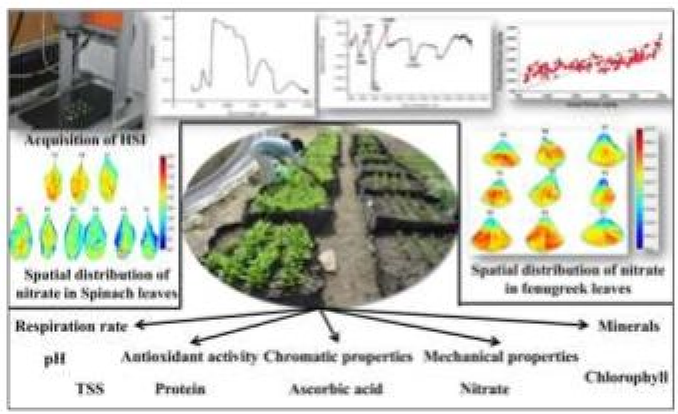
Despite the harmful consequences, chemical pesticides are widely used worldwide in agricultural production systems. The only alternative to chemical pesticides is bio-pesticides, which are biological microbes that act as pest control agents. Currently, bio-pesticides are applied through the existing spraying systems meant for chemical pesticides; thus, the exposure to mechanical stresses developed due to different components of the spraying system causes permanent damage to the viability of friendly microbes of bio-pesticides.



Therefore, an efficient method of bio-pesticides delivery for foliar spray application has been developed to have maximum viability of microbes in the bio-pesticides solution. Two different classes of bio-pesticides, viz. bacterial-based *Bacillus thuringiensis* (BBP solution) and fungal-based *Beauveria bassiana* (FBP solution), are evaluated for spray discharge by three hollow cone nozzles (1.14, 2.35 and 3.56 mm diameters in size) at four operating pressures (145, 245, 345 and 445 kPa). The viability of bio-pesticides increases as operating pressure decreases, nozzle size increases, and pumping pressure increases. At the same time, spray quality decreases, thus contradicting the trend with operating pressure and nozzle diameters. The optimized values of variables, are nozzle orifice size of 3.56 mm, at an operating pressure of 145 kPa, at an application rate of 323.94 L/ha, a volume median diameter (VMD) of 225.88 μm, with a coefficient of variance (CV) of 84.49% and viability of 6.63×10^6 for BBP solution; whereas, the same for FBP solutions are nozzle orifice size of 3.56 mm, operating pressure of145 kPa, at an application rate of 325.58 L/ha, VMD of 231.89 μm with a CV of 85.99% and viability of 6.163×10^6.

Vis-NIR Hyperspectral Imaging Protocols for Estimation of Nitrate in Harvested Leafy Vegetables (PhD holder: Naveen Kumar Mahanti; Supervisor: Subir Kumar Chakraborty)

The overuse of nitrogenous fertilizers leads to an increase in the nitrate content of green leafy vegetables. Consumption of food with excess nitrate leads to various ailments in human beings. In the present study, spinach and fenugreek leaves were harvested from plants grown under different nitrogenous fertilizer doses (0-400 kg N/ha). Spectral data and hyperspectral images of total 261 leaves were acquired using a spectroradiometer (350-2500 nm) and hyperspectral imaging (HSI) (398-1003 nm) camera. Partial least square (PLS) regression

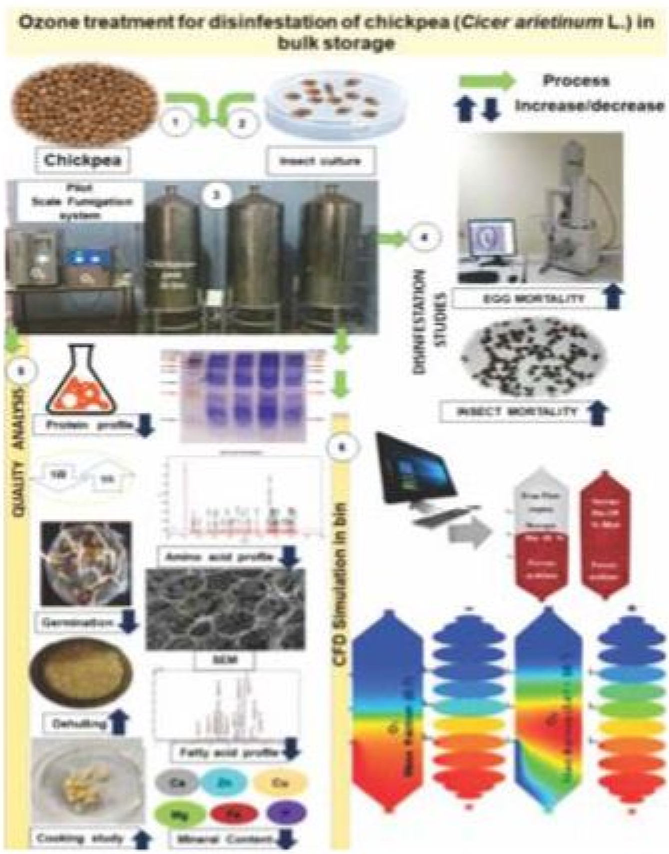


models were developed using whole spectra and featured wavelengths. The PLS model developed with MSC+SNV and detrending pre-processed spectral data was more effective for spinach and fenugreek, respectively. The effective wavelengths for measurement of nitrate content in spinach leaves were identified as 558, 706, 780, 1000 and 1420 nm and 483, 550, 664, 714, 1012, and 1401 nm for fenugreek leaves. The nitrogen fertilizer dose had a significant positive effect on chlorophyll, carotenoid content, a^*, hue angle, pH, nitrate, and protein, however, negative effect on L^*, b^*, chroma, TSS and mechanical properties of both the leaves. The total polyphenols (TPP), antioxidant activity of both the leaves increased with an increase in fertilizer dose from 0-50 kg N/ha; it further decreased with an increase in fertilizer dose. The fertilizer dose had a significant effect on the mineral content of both the leaves. The *T*, *t* and nitrate content of leaves had significant effect on quality of both the leaves during storage.

Ozone Fumigation for Disinfestation of Chickpea (*Cicer Artienum* L.) in Bulk Storage System

(PhD Holder; Nickhil C, Supervisor: Debabandya Mohapatra)

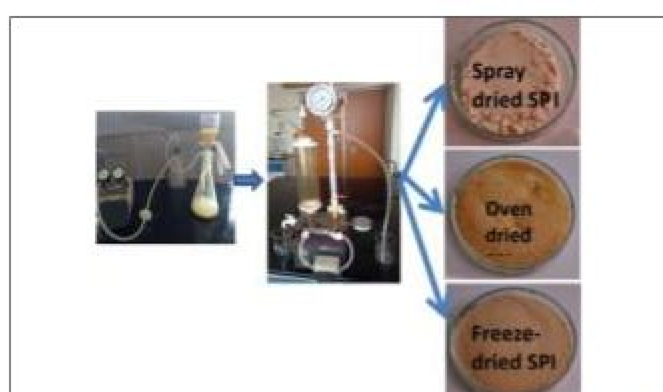
Chickpea grains are mostly attacked by insects during storage, thus reducing their nutritive as well as market value. To avoid the incidence of the insects, the approach of gaseous ozone treatment is a suitable disinfestation technique for grains stored in bins, for its potential oxidizing and residue-free nature. The present study attempts to disinfest *Callosobruchus maculatus* in stored chickpea at different ozone gas concentrations (500-1000 ppm) varying moisture content (10-14% wb), storage temperature (18-31 °C), and grain bed thickness (50-100 m). At a higher ozone concentration approach, the results revealed 100% and zero% of adult and egg mortality. The surface morphological studies spotted the collapse of the eggshell of the insect to the tune of 5-38 μm in dimension. The numerical simulation of ozone flow in the grain storage bin revealed that the mass fraction at different inlet conditions at the bottom, middle and top was one at the lower, centre and top regions of the storage bin in the 100% grain fill condition having diffusion coefficient between 1×10^{-10} to 1.725×10^{-5} (m^2/s) after 15 min. In the pilot scale storage for 6 months, ozone-treated samples achieved 100% adult mortality, 0% egg hatching, 13% amino acid reduction, 89% dehulling efficiency, and 29 min cooking time, whereas the untreated sample has 12.7% adult mortality, 81% egg hatching, 26% amino acid reduction, 42.1% dehulling efficiency and 32 min cooking time. Hence, ozone fumigation can be recommended for chickpea grains.



Soy Protein Isolates Production Using Ultrafiltration Technique

(PhD holder: Hima John, Supervisor; Lalan Kumar Sinha)

Soy protein isolate (SPI) is the purest form of soy protein having many industrial and food applications because of its high protein content. Ultrafiltration (UF) is eco-friendly, energy saving and water-conserving process to produce SPI with enhanced functional properties. SPI has been prepared using UF, and different drying methods. Optimized parameters for UF are membrane module of 13.38 kDa, transmembrane pressure of 117.21 kPa, volume concentration ratio of 3.6, diafiltration of 1 time and flow rate of 63.04% of pump capacity with a predicted permeate flux of 11.13 LPH, protein content in retentate 85.52% and protein rejection 98.99%. Optimized Spray drying conditions are inlet air temperature of 180 °C and airflow rate of 0.02 m^3/min to get maximum protein yield (97.59%) and minimum moisture content (5.4%). Optimized oven drying conditions are drying temperature of 47 °C and drying time of 48 h to get maximum protein yield (98.27%) and minimum moisture content (4.42%). Overall protein yields from spray drying, oven drying, and freeze drying were 33%, 43%, and 54% respectively. Ultra-filtered spray dried SPI exhibited the highest values of water solubility index (8.3%), oil absorption capacity (3.2 mL/g of protein), with nitrogen solubility index of 94% and protein dispersibility index of 95%. The storage proteins (11S and 7S) are superior in ultra-filtered SPI spray dried and freeze-dried SPIs (73% and 76%, respectively). Hence UF along with spray drying or freeze drying can be recommended as a potential alternative to conventional methods for producing high-quality SPIs.



SUCCESS STORIES

Success story - Mechanization package for rope making from outer sheath of banana pseudo stem

The package of equipment for banana pseudo stem splitting and outer sheath rope twisting & winding has been developed to convert outer sheath of banana pseudo stem to make twisted ropes. It has a novelty, generation of wealth from waste. It shows higher efficiency, higher output and reduces drudgery significantly as compared to its traditional method. It has provisions to produce varied number of twists per unit length to suit the requirements of value-added product to be made out these ropes. Moreover, the twisted ropes are wound in bobbin, which ease the safe handling and transportation. Generally, these twisted ropes are used for the production of various eco-friendly handicraft products (local/international market) viz., bags, window curtains, table mat etc. A manufacturer based at Coimbatore M/s Trytex Machine Company have signed a MoA with Agri innovate, New Delhi for its commercial production. The technology has been identified under ABI of ICAR-CIAE, Bhopal and ICAR-NRCB, Trichy.

Commercial prodcution of the banana outersheath twisting and winding equipment by manufacturer by lecensing through Agri innovate, New Delhi

Adoption of Drip-tape technology paves way for coriander profitability in Coimbatore district of Tamil Nadu

Mr. P. Palanisami, a progressive farmer from Pethikuttai village (ICAR-CIAE Regional Centre, Coimbatore adopted village through SCSP), adopted the drip-tape technology for coriander cultivation in 0.3 ha area. With the implementation of technology during rabi season 2020, he experienced an improved benefit as compared to traditional irrigation method viz., labour reduction in irrigation, fertilizer application, weeding cost etc. The adoption of technology helped in harvesting a good quality coriander (greenish, tenderness and fragrance) leaf produce, which fetched better market price (₹3.00/100 g bundle) as compared to traditionally cultivated coriander (₹2.5/100 g bundle) in the market of Coimbatore. He has benefitted through higher profit

of ₹34000/ha with the adoption of drip-tape technology by enhancing the coriander yield to 865 kg/ha and reducing the total cost of cultivation by ₹4,080/ha as compared to traditional irrigation practice. The higher benefit cost ratio of 2.95 indicated that the farmer gained higher return from drip-tape technology of irrigation.

Income generation through establishment of custom hiring Centres of Agricultural Machinery by farmers of Satna and Jhabua Districts of MP.

Shri Pushpendra Bagri is a resident of village Unchehra in Satna district. He owns about 3.25 ha land. To augment his net income, he became interested in custom hiring business of agricultural machinery in his village and received training from ICAR-CIAE, Bhopal during March, 2020 after enrolling in entrepreneurship development programme with the Directorate of Agricultural Engineering, Government of MP. After completing the training successfully, he established the custom hiring business centre in April, 2020 with an investment of ₹ 23.0 lakh by taking loan from bank with 40% subsidy. In the beginning, he bought two tractors and a set of trolley, reversible MB plough, rotavator, raised bed planter, seed drill, straw reaper and cultivator. With active help from his family members, he is running day-to-day business of the custom hiring centre. He is renting out these machinery to farmers in his village and surrounding villages for cultivation of field crops like soybean, wheat, chickpea and other pulses. He has generated an income of about ₹ 7.0 lakh in a year with a net profit of about ₹3.5 lakh in 2021. Similarly, Jitendra Rawat, a resident of village Navapada in Jhabua district, who owns about 3 ha land, received the same training from ICAR-CIAE, Bhopal. Subsequently, he also established his custom hiring business centre in April, 2020, with an investment of ₹13.8 lakh by availing loan facility from bank. He also purchased the same set of machinery as that of Shri Bagri of Satna district and started the business of the custom hiring centre by renting out these machinery among farmers in his village and surrounding villages for cultivation of field crops like soybean, wheat, chickpea and other pulses. He has generated an income of around ₹ 2.5 lakh in the year with a net profit of about ₹1.5 lakh.

SALIENT ACHIEVEMENTS under AICRPs and CRPs

AICRP ON FARM IMPLEMENTS AND MACHINERY

Tractor Operated Turbo Bund Former for Mulched Fields

Paddy straw management is a major concern, since a very short time span is available between paddy harvesting and wheat sowing, and it is challenging to form bunds in mulched fields. Therefore, a tractor-

operated bund former for mulched fields has been developed and evaluated under field conditions at PAU, Ludhiana centre. The machine carries out straw removal (up to 1.25 m width) followed by soil pulverization and formation of trapezoidal-shaped soil bund, simultaneously in one pass. It consists of a mulcher, rotavator and bund forming unit. Mulcher removes straw from the front of the rotavator at an width of 1.25 m. The rotavator blades are arranged in pairs on each side of the flange alternately in a staggered position, which pulverizes the soil at 210 rpm. Discs are inclined at 45° to for smooth culting of the soil and residues. Discs are positioned just behind the rotavator to carry the tilled soil and pile it in the form of bund. The effective field capacity of the developed tractor-operated bund former is 1.28 ha/h at a forward travel speed of 0.42 m/s. There is a saving of 78% in labour over the conventional bund forming.

Tractor Operated Potato Digger-Cum-Collector

In India, potato harvesting is done either manually or with a mechanical digger. In operation of a potato digger, dug potatoes fall behind the machine wich are collected by laboratories. This is a labour-consuming process and increases the crop production cost. To address this problem, a tractor-operated potato digger with a collection mechanism has been developed and evaluated in sandy loam and loamy soil by PAU, Ludhiana centre. It performs digging of potato tubers (two rows), separation of potatoes from the soil, and collection of potatoes in the collection unit. The effective working width of the machine is 1 m. A hydraulic system is installed to unload the collection unit. The best results have been obtained at a forward speed of 0.42 m/s and blade depth of 140 mm for both soil types. The collection efficiency, cut, bruise and fuel consumption for sandy

loam soil and loamy soil are found to be 98.78%, 0.68%, 1.96%, 4.27 L/h and 0.71%, 1.95%, 4.68 L/h, 98.73%, respectively. The average field capacity and output capacity have been recorded as 0.12 ha/h, 2700 kg/h for sandy loam soil and 0.11 ha/h, 2685 kg/h for loamy soil, respectively.

Self-Propelled Small Maize Harvester

Presently, maize cob harvesting is done manually in India, which is a tedious, time-consuming and drudgery-prone operation. Therefore, a self-propelled walk-behind maize harvester has been developed to mechanize these operations at TNAU, Coimbatore centre. It consists of rollers mounted at different levels to collect the harvested cobs in the box provided at the side of the rollers. Two star-wheels are mounted at the front

of the unit at different heights above the rollers. As the harvester moves forward, the star wheels and guide-rods guide the plants between the rollers by pulling them between the snapping bars. The maize cobs that cannot pass through the spacing between the snapping bars and cobs are sheared off from the plants. A horizontal rotary cutting blade is provided at the bottom of the harvester to cut maize stalks at ground level. An 11 hp diesel engine powers the drive for snapping rollers and the rotary blade. The field capacity and cost of operation of the harvester are found to be 0.19 ha/h and ₹2850/ha, respectively. It saves 25, 96 and 91% in the cost of operation, time and labour, respectively, over the conventional harvesting method.

Multi- Row Rotary Weeder Attachment to Ride on Rice Transplanter

Manual weeding in the transplanted rice field is a tedious and drudgery-prone operation. Therefore, a multi-row rotary weeder as an attachment to the riding type rice transplanter has been developed at TNAU centre. The drive for the weeding unit is taken from the PTO of the tractor. Two models of weeding units are

developed. In the first model, five rotary finger-type weeding rollers are used; each roller has four weeding fingers. The rollers are mounted at a spacing of 300 mm, which are adjustable. The rotary weeding rollers and floats are mounted at the rear side of the transplanter. In the second model, five serrated blades and five plain blades are alternatively arranged on the circumference of rollers. Six rotary weeding units are mounted on the shaft, whereas one more weeding unit is mounted behind the gearbox. The field capacity of the developed weeder is 0.31-0.38 ha/h, and it saves 70 and 68% of time and cost of operation, respectively. The width of the rotary unit is 150 mm.

Tractor-Operated Paper-Tape Vegetable Transplanter

Vegetable transplanting is a drudgery-prone and time-consuming operation that requires about 25-32

man-days/ha. In India, vegetable transplanting is mostly done either manually or with a desire in which feeding of seedling is done manually. Mechanical seedling pickup and drop are challenging operations. Numbers of attempts have been made to automate vegetable transplanting. Therefore, a tractor-operated multi-row paper-tape vegetable transplanter has been developed by CCSHAU, Hisar centre. The equipment consists of a frame, tray, guiding way, furrow opener, and covering system. A maximum of six rows can be planted in one pass of the machine. The field trial of the developed machine was conducted using a 24 hp tractor at a forward speed of 0.58 m/s. The row to row and plant to plant spacings are maintained at 300 and 160 mm, respectively. The field capacity and field efficiency of equipment are found to be 0.25 ha/h and 65.8%, respectively. The missed planting, tilted planting and seedlings covering per cent are observed as 0, 3.14 and 94.33%, respectively. The cost of operation of the machine is ₹660/h.

Sensor-Based Site-Specific Chemical Applicator with Remote-Controlled Navigation

Agrochemicals play a vital role in protecting crops from insects, fungi and weeds. In the conventional spraying system, there is no cut-off mechanism to avoid spraying between plants due to which liquid chemical flows continuously from the nozzles on the plant canopy and skips void space, which results in 50-60% of wastage in applied chemicals and increases disease control costs. Operators exposure to hazardous chemicals, wastage of chemical inputs, and degradation of the environment are serious issues with the conventional method of chemical application. Therefore, ANGRAU, Bapatla centre has developed a remote-controlled sensor-based site-specific chemical applicator. The remote-control unit helps the operator to run the chemical applicator without entering the field, and the sensors help in spraying exactly on the plant canopy and avoid off-target spraying. The average forward speed of the chemical applicator is 0.61 m/s. The average discharge

of the boom is 1.1 m^3/s. The actual field capacity and field efficiency of the developed chemical applicator is 0.263 ha/h and 61.73%, respectively. The cost of operation of the developed chemical applicator for the chilli crop is ₹125/h.

Micro-Controller Based Precision Planter for Maize and Cotton

Maize and cotton are two important crops. The cost of the cotton seed is very high and required to be sown precisely. A single seed must be placed to reduce seed wastage and input cost. Generally, the metering mechanisms of planters are driven by ground wheels through chain and sprockets. Skidding of the ground wheel alters the seed rate. The commercially available precision planters are of high cost and not affordable to small and marginal farmers. To overcome the above problems PJTSAU, Hyderabad centre has developed a low-cost micro-controller-based precision planter for maize and cotton crops and evaluated it in the field. The

average missing index, multiple index and quality feed index of microcontroller operated planter is 6.6, 10, and 83.4% as compared to 20.3, 23.3 and 56.4%, respectively, for ground wheel operated planter. The effective field capacity and field efficiency of microcontroller operated planter are 0.35 ha/h and 78%, respectively. The fuel consumption of the microcontroller-operated planter is 3.5 L/h, whereas, in the case of a ground wheel-driven planter, it is 3.8 L/h.

Two Row Electric Rice Transplanter for Root-Washed Seedlings

Mostly rice transplanters require paddy seedlings grown in a mat-type nursery. The preparation of a mat-type nursery is a laborious and time-consuming operation. Therefore, a motor-operated 2-row rice transplanter has been developed at BAU, Ranchi centre, for root wash seedlings. It consists of a picking mechanism, transplanting mechanism, power transmission system, float assembly, seedling tray, a handle and ground

wheel. Two D.C. motors are used as a power source for the transplanting mechanism and ground wheel. The motor is attached so that it can perform seedling picking and transplanting through cam-shaft assembly with the help of chain and sprocket arrangement. Two dry lead-acid batteries (12 V, 7 Ah) are used as power sources for the motors. A provision has been made to attach/detach the transplanting unit with the ground wheel as per suitability. The effective field capacity and field efficiency of the developed transplanter are 0.04 ha/h and 85%, respectively, at an average operating speed of 0.28 m/s. Average visible damage, floating hills and missing hills are found to be 4.5, 9 and 10.5%, respectively. The cost of transplanting is ₹2,620/ ha.

AICRP ON INCREASED UTILIZATION OF ANIMAL ENERGY WITH ENHANCED SYSTEM EFFICIENCY

Cattle Dung Collection Machine

An average small-scale dairy farmer has 3-5 cattles in his dairy barn for his livelihood. Dung of cattles is collected by hand. These dairy farmers cannot afford to purchase a commercially available costly cattle dung collecting machine. Therefore, it is required to develop a

small-sized low-cost dung collection machine for small dairy farmers that would permit a practical and hygienic collection of cattle dung and provide a clean environment for animals. IGKV, Raipur centre, has developed a power-operated dung collection machine. It consists of a frame/platform, an electric motor, an air compressor, and a suction unit with a collection chamber. The overall dimensions of the developed dung collection machine are 970×715×850 mm. The suction pressure required for the collection is 77 kPa. The capacity of the collection chamber is 60 kg. The collection capacity and collection efficiency on smooth and rough surfaces are obtained as 59.68 kg/h 47.02 kg/h, and 93.80% and 74.10%, respectively. The capacity is highest at a forward speed of 0.5 m/s in collecting dung. The cost of operation of the machine is ₹70 /h.

Animal Drawn Single Row Potato Planter for Hilly Region of Chhattisgarh

Potatoes are largely planted by hand in Chhattisgarh, in 85% of the cultivated land. Since the draught animals are a popular source of farm power and the scarcity of appropriate equipment for the small and marginal farmer is a major issue, IGKV, Raipur centre, developed an animal-drawn single-row potato planter. The metering mechanism of the planter includes bracket cups, seed metering chain, drive wheel, metering shaft, fluted roller, and seed metering duct. The developed machine is tested for its performance with 3 different shaped potatoes viz. round, oblong, and long oblong. Its field capacity is 0.09 ha/h with 66.5% field efficiency. The average draught required to pull the developed machine is determined as 660 N at 0.56 m/s forward speed. The average power required to operate the potato planter is determined as 0.40 kW. The average depth of seeding is found 150 mm. The cost of planting

with the developed planter is estimated as ₹1610/ha. Damages are observed as 1.49, 1.65, and 1.86% for round, oblong, and long oblong shapes tubers, respectively.

Bullock Drawn Four Row Seed Drill for Millets

In Odisha, the small and marginal farmers generally follow manual line sowing of millet seeds behind bullock-drawn desi plough under upland conditions. It consumes more labour, time, and cost. Therefore, OUAT, Bhubaneswar centre, has developed a four-row seed drill for line sowing of millets (finger millet, little millet, sorghum) and is operated by a pair of medium-size bullocks. It consists of a mainframe, hitching arrangement, seed box, inverted 'T' type furrow openers, inclined plate metering mechanism, transport-

cum-depth control wheels, and ground wheels. The weight of the seed drill is 67 kg, with an overall dimension of 1150×1300×900 mm. The field capacity of the seed drill is found to be 0.12 ha/h with 62.7% field efficiency at 0.52 m/s speed for finger millet sowing. The seed rate is found to be 5.5 kg/ha. The draft and power requirements are observed to be 377.7 N and 0.19 kW, respectively, which are within the draughtability of a pair of bullocks. A demonstration on the use of bullock-drawn 4-row seed drill for sowing of millets has been done in 8 blocks in 4 districts of Odisha under the mechanization of millets in the tribal area.

Animal Drawn Seed-Cum-Subsurface Manure Applicator

The application of organic manure in the field is an important operation in crop production. Organic farming is one of the options to enhance the health of the soil and improve production simultaneously. The nutrients and water are absorbed by the roots of plants from the soil to achieve optimum productivity. In view of the above concern, an animal-drawn seed-cum-subsurface manure applicator has been developed by

GBPUAT, Pant Nagar centre, for the application of manure at a depth of 100 mm below the soil surface, which is capable of dispersing the manure at the sub-surface uniformly and takes less time as compared with the manual broadcasting method. It simultaneously sows the seeds at the desired depth. A cup feed mechanism is found suitable for the animal-drawn seed-cum-subsurface manure applicator. The manure drop per meter length is found to be 0, 60.81, 65.93, 77.62, 169.8, and 186.6 g at the rotor shaft speed of 0, 45, 65, 95, 105, and 125 rpm, respectively.

Animal Operated Rotary System for Threshing-Cum-Cleaning of Pearl Millet

Generally, pearl millet crops are threshed manually, followed by winnowing with a bamboo-made swinging

basket, which is exceedingly labour-intensive, tedious, and uneconomical. Therefore, the OUAT centre has developed a pearl millet thresher-cum-cleaner for threshing and cleaning of harvested and dried pearl millet simultaneously with a pair of bullocks. The threshing cylinder shaft gets drive from the bullock-operated rotary system by belt and pulley systems. The blower and aspirator are mounted on the cylinder shaft. The sieves are attached to the threshing cylinder shaft by a cross belt and pulley drive and operated by an eccentric mechanism. The developed thresher-cum-cleaner has an average output capacity of 31.58 kg/h, with a threshing and cleaning efficiency of 95.05 and 97.65%, respectively. The speed of rotation of the main shaft and blower shaft is measured to be 562 and 598 rpm, respectively, while the speed of bullocks is 0.52 m/s. The average air velocity is measured as 8.3 m/s. The draft and power requirement of the sorghum thresher-cum-cleaner is found to be 464 N and 0.24 kW, respectively. The overall fatigue score of bullocks is found to be 14 after 1 h of continuous operation, indicating that they can operate the equipment comfortably.

Improved Animal Housing Structure for Draught and Milch Animals

The draught and milch animals require good health for better production and productivity. The summer season causes discomfort for them due to higher air temperatures, which can be modified by incorporating an artificial air cooling system. Therefore, UAS, Raichur centre developed a solar power-assisted air cooked animal housing structure to provide cooling to animals. A solar panel of 36 W is provided to operate a DC pump with an automatic time-controlled switch at a discharge rate of 5.5 L/h. The time-controlled switch installed inside the animal housing structure is set for 10 minutes ''on'' position and 10 minutes ''off'' position for the creation of a cooling effect using the fogger assembly. The 26 foggers are operated with the solar-powered DC pump. The air temperature inside the animal housing structure is observed to be 4 °C lesser compared to the outside air temperature with 59.40% relative humidity. This improved structure is found to be more comfortable for animals with respect to the least change in physiological responses and higher intake of dry matter and digestibility as compared with existing structures.

AICRP ON ERGONOMICS AND SAFETY IN AGRICULTURE

Pollinator for Greenhouse

Greenhouses have been accepted worldwide for the round-the-year cultivation of quality produce. A greenhouse provides a desired climatic condition for crops but at the same time causes obstacles to natural pollination. Therefore, a pollinator for the greenhouse has been designed by ICAR-IARI New Delhi centre on the principle of a pulsating air jet for pollination. Three pulsation units have been used to provide varied air pulsation frequencies and angular movement to cover the entire flower bed. An operator in the greenhouse alleys can easily move the unit. The developed unit is compared with hand pollination and pollination by a blower in tomato crops. The highest pollination efficiency (83.66%) is achieved at 1.99 m^3/min airflow rate, 23.50 Hz pulsation frequency, and exposure time of 19.40 seconds. An average yield of 19.52 kg is observed at 1.99 m^3/min of airflow rate, 22.25 Hz of pulsation frequency and exposure time of 15.78 seconds in flowers of 5 m length sections. A higher yield is reported with this pollinator compared to pollination by a blower and a controlled plot. Mean values of ODS (Overall discomfort score) and HR varied from 1.75-2.25 and 90.99-127.65 bpm, respectively, in pollination by the developed pollinator. The cost of operation is ₹400/ha, as compared to ₹1500/ha with manual hand pollination. The breakeven point is 75 hours/year with a payback period of two years.

Braking System for Electrical Motor Operated Chaff Cutter

When a power supply is cut off in a motor-operated chaff cutter, the chaff cutter's belt still rotates and takes time to come to a halt because of flywheel inertia. Therefore, a hydraulic disc brake is integrated with the electrically operated chaff cutter and the electrical brake to overcome the flywheel rotation issue by ICAR-IARI, New Delhi centre. The application of a manual lever stops the flywheel, and the current flow is stopped to the motor, activating the electric brakes through the relay. Thus, complete braking is achieved within a fraction of second. The angle covered by the flywheel and the time required for stopping the flywheel has been observed using tracker video analysis software. A number of high-resolution videos were analysed with fodder and no fodder conditions, and it is found that the time required for stopping the chaff cutters using the developed systems is less compared to the human reflex action time for audio 155 milliseconds (ms), touch (170 ms) and visual (200 ms). The observations showed that the brake time for manual and powered chaff cutters is 9 ms and 11 ms, respectively. The results showed that the braking time for both systems is safe. Along with this, the angle covered during the respective braking cycles is found to be 145.8° and 164.3°.

Ergonomic Evaluation and Modification of Grass Cutter-Cum-Paddy Harvester

Operating the existing grass cutter-cum-harvester is drudgery-prone and tedious. Therefore, a modified two-wheel-drive grass cutter-cum-paddy harvester has been developed at BSKKV, Dapoli centre, considering various anthropometric dimensions of the male workers from the Konkan region. It consists of an engine (1.95 hp), a handle, a two-wheel drive trolley, a cutting blade and a drive shaft as the main components. A rotary

cutting blade is provided for paddy harvesting. The performance of the developed machine is evaluated ergonomically for harvesting paddy and compared with the existing machine. The working Heart rate (HR), working oxygen consumption rate, and change in HR of the subjects for paddy harvesting with the developed machine are found to be 122.25 (± 13) basic metabolic panel (BMP), 1.07 (± 0.2) L/min, and 43.5 (± 12.2) BMP, respectively. The average energy expenditure rate and field capacity of equipment are 22.29 (±5.2) kJ/min and 0.012 (± 0.01) ha/h, respectively. The field capacity of the machine for grass cutting is 0.04 ha/h.

Ergonomically Designed Engine Operated Auger Digger for Farm Women

A portable auger digger is very useful for digging small pits for planting tree seedlings or gardening, but the vibration and strain produced in diggers while digging pits causes muscular-skeletal disorders. Hence, an attempt has been made to study the vibration level in the engine-operated portable auger and to develop a portable women-friendly auger digger at the TNAU centre. This movable auger digger is contemplated and a frame with two wheels is developed so that the digger can easily be moved from one place to another place by women workers. The auger digger is tested for its performance in black cotton soil with a moisture content of 11.6% (db), soil bulk density of 1.3 kg/cm^3 and cone penetration index of 48 kg/cm^2. The RMS of the auger digger is found to be 0.0919 m/s^2. The hand-arm vibration is less than the EAV of 2.5 m/s^2 and the ELV of 5 m/s^2. The entire unit can be moved from one place to another place, where the 60.8 N force is required to pull the unit, which is within the force exerted by a normal female worker. The unit can also be pushed with a force of 55 N. Hence, for easy transport and handling, with less energy expenditure, the auger digger may be used. The mean O_2 consumption is found to be 0.957 L/min, where the energy expenditure is 4.84 kcal/L. The transport of the auger digger is easy, and women can manage digging of holes. There are savings of 31.8 and 40% in time and cost of operation, respectively.

Tractor Operator Ingress-Egress and Hand Control Systems for Specially-abled Farmers with Lower Limbs

In India, 2.21% of the total population is disabled, among which 20% have a disability in movement. They cannot be engaged in tractor driving. An ingress-egress system has been developed with a hand-operated control system at the IIT Kharagpur centre. Agricultural tractors available in the centre are investigated for locations of controls and operator's seats. The maximum actuating force required for the clutch pedal is found to be 176 and 164 N during transportation on tarmacadam roads and farm roads, respectively. The force required for the brake pedal is found to be 204 and 173 N on tarmacadam and farm roads, respectively. An ingress-egress system is a sensor-based wireless hand control system that uses a microcontroller, relay switch, RF module, electric linear actuators, and keyboard to make the tractor foot controls suitable for lower limb impaired persons. It further consists of a

transmitter and a receiver to operate the brake and clutch pedals. Electric linear actuators are connected to the pedals with chain linkage to facilitate them to be operated freely and smoothly. The response time of the developed sensor-based wireless hand control system was measured using a digital oscilloscope. The time required to engage the brakes is 2.02 sec, and to disengage the clutch is 2.84 sec.

Analysis of Agricultural Accidents from Agricultural Accidents Survey App

A multilingual (English, Hindi, Odia, Tamil, Punjabi, and Marathi) Agricultural Accidents Survey APP has been developed for collecting data from Madhya Pradesh, Sikkim, West Bengal, Arunachal Pradesh, Assam, Odisha, Tamil Nadu, Rajasthan, Haryana, Punjab, Himachal Pradesh, and Maharashtra. The developed app is user-friendly and can be operated by persons using any android-based mobile phone.

The Backend Agricultural Accidents Survey software is accessed through the link http://14.139.59.149:8090/AccidentSurvey/LoginServlet. This software is user-restricted and needs authentication to access it. It has three levels of authentication, viz., coordination cell (admin), state-level authentication (AICRP centres admins), and village-level authentication (field investigators). The data entered through the "Agril Accidents Survey App" can be accessed to view, correct, and generate reports through this software. The software has the following menus 1. Masters – to access the database of states, districts, tehsils, villages, equipment, and crops. 2. Reports – to generate reports of incidences, the number of victims, classifications, factors, economic loss, etc. 3. Change password- to change passwords. 4. Add admins/ surveyors – to add state administrators for monitoring the progress of surveys and also add surveyors to carry out survey work. 5. Show state admin – to show all the state administrators. 6. Manage state admin – this option will helps to add/block administrators. 7. Assign villages – to assign villages to the surveyors 8. Show village details – to see all the details of village information that were entered by the surveyors along with the uploaded photographs. 9. Show incidences details – to see the number of accident incidences in the villages. 10. Show village details history- to view the time series data of the accident information of the village. Further, the software has the capability to analyse and generate tables, and reports of villages, states, and all of India as per the authentication.

AICRP ON ENERGY FROM AGRICULTURE AND AGROBASED INDUSTRIES

Evacuated Tube Collector Solar Dryer

The solar dryer consisting of conventional evacuated tubes has been designed and fabricated at PAU, Ludhiana centre of ACIRP on EAAI. The dryer has a loading capacity of about 30 kg. There is a problem with the availability of evacuated tubes that are open at both ends. The new design of the dryer employs a

conventional evacuated tube collector, i.e. the evacuated tubes open at one end only. Conventional evacuated tubes are the tubes used in solar water heaters. The dryer's performance has been observed to be satisfactory for drying Moringa leaves (*Moringa oleifera* l).

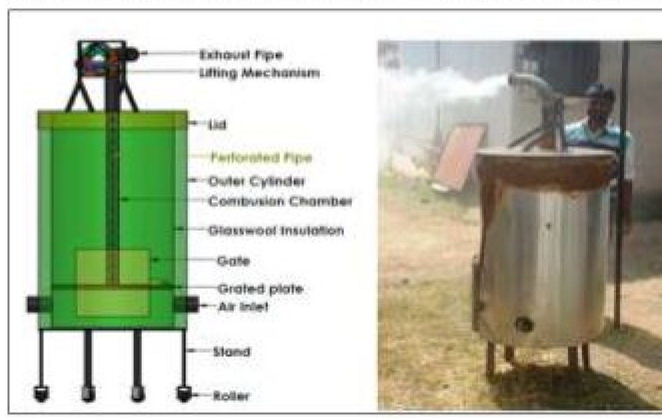
Fermentor for Lignocellulolytic Enzyme Production

The PAU, Ludhiana centre of AICRP on EAAI, designed and fabricated a field fermentor of 500 L capacity having dimensions 0.9 m×1.5 m and installed at the demonstration area of the Department of Renewable Energy Engineering. The various trials for producing lignocellulolytic and silicolytic enzymes were conducted in the field fermentor using various fungal and bacterial cultures. Partially purified enzyme extract from

biodigested slurry using *P.chrysosporium* was compared with all commercially available lignocellulases from different fungal sources. The specific activities of almost all the lignocellulolytic enzymes, viz. Cellulases, Hemicellulases laccase, lignin peroxidase and manganese peroxidases were at par with commercial enzymes. More lignocellulolytic enzymes were produced using Bio-digested Slurry (BDS) compared to the standard medium, which saves about ₹5800-13000/batch of 200 L. Paddy straw supplemented with a bio-digested slurry containing crude enzymes produced a maximum of 257.97 L biogas /kg paddy straw compared to 219 L of control, indicating a 17.3% increase.

Small Scale Portable Biochar Kiln

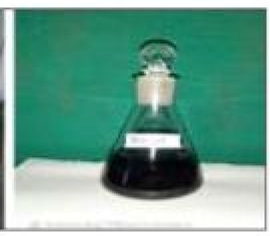
The BAU, Ranchi centre of AICRP on EAAI developed a small-scale portable biochar kiln for biochar production utilizing agricultural waste residues. The unit consists of



a kiln of cylindrical shape, a gated opening for the burning bed, and perforated pipes for the transmission of exhaust gases. The Kiln was tested with wheat straw and groundnut husk. About 3.5 kg of wheat straw and 4.2 kg of groundnut shell were fed separately and packed by opening the lid into the combustion chamber. The biomass was held in between the grated plate with a layer of firing coal. Burning was made by opening the ash chamber gate. The recorded temperatures during the process of pyrolysis were 312 °C and 320 °C for wheat straw and ground nut shell, respectively. Actual time required for complete conversion for wheat straw was 92 minutes and that of groundnut shell was 123 minutes. Average Biochar yield in case of wheat and ground nut shell was found out to be 28.85% and 31.42%, respectively. Carbon content of groundnut shell was found to be 71.6% and that of wheat straw was 62.94 %.

Improved Pyrolysis Process for Conversion of Pine Needle Bio-Oil into Liquid Bio-Fuel

The GBPUAT, Pantnagar centre, has developed an upgraded pyrolysis process for converting pine needle pyrolysis bio-oil into liquid biofuel. Pine needles are the abundantly available biomass of pine forests, which are present throughout the globe. Past studies have shown that pine needle bio-oil can be used as fuel in diesel engines but found higher carbon after removing high carbon residue. Experiments were conducted to convert pine needles into bio-oil and biochar through a catalytic pyrolysis process. The catalyst ZSM-5 and CaO were used with pine needle biomass in a ratio of 10, 20 and 30%. Process parameters such as pyrolysis temperature, gas flow rate, vapour cooling temperature, and heating rate were optimized by employing central composite design (CCD) in Response Surface Methodology (RSM).



A maximum yield of 24% bio-oil was found under optimized conditions for ZSM catalyst, whereas 13% bio-oil recovery was obtained in the case of CaO.

Demonstration and Training of Large Scale Controlled Solar Tunnel Dryers

PDKV, Akola centre conducted the demonstration and training of large-scale controlled solar tunnel dryers. The solar tunnel dryer was demonstrated to a group of farmers from Village Ujaleshwar, Dist Akola. The farmers have an agro-processing company named M/s Appa Swami Agro Produce Company, which primarily deals with the cultivation of medicinal crops as contract farming. A detailed demonstration of the system was given to the representative of the farmer's company at the centre for drying of *Shatavari* crop. During the demonstration, 30 tonnes of *Shatavari* drying was completed.

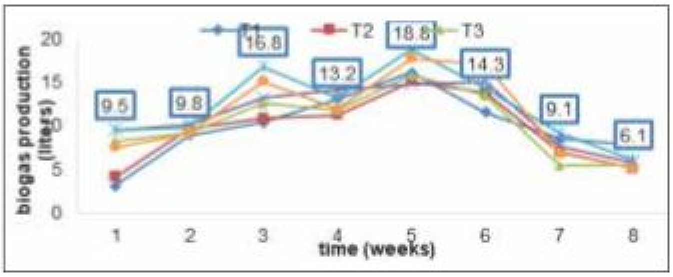
Demonstrations of Solar Insect Trap

SPRERI, VV Nagar centre procured 10 solar insect light traps from MPUA&T, Udaipur centre . The performance of the battery back-up was evaluated at SPRERI campus. Total 8 nos. of solar insect light traps were demonstrated on two farms in Haldari and Isnav villages of Gujarat state. SPRERI team monitored all traps and collected Insects on a daily basis. All these insects were identified

with the support of the Head of Entomology Department, B.A. College of Agriculture, AAU. The trapped insects were found to be from the Hemiptera, Lepidoptera, Hymenoptera, Diptera, Coleoptera, Orthoptera insect families.

Enhancement of Biogas Production Using Nanoparticles under Batch Digestion

The CCSHAU, Hisar centre, utilised nanoparticles to enhance biogas production under batch digestion. After



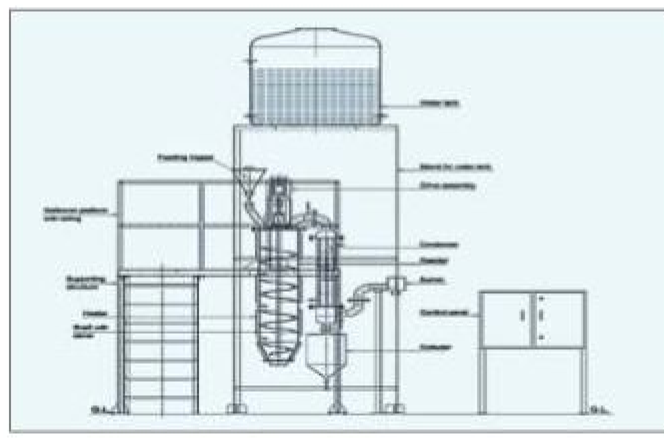
synthesising and characterising iron nanoparticles. They were supplemented with cattle dung for enhancement of biogas production. The biogas production increased rapidly during the fifth week of anaerobic digestion. The biogas production was enhanced by supplementation of cattle dung with different concentrations of iron nanoparticles and maximum field was found in T5 (104.3/L) followed by T6 (95.4/L) as compared to T1 (85.2/L) after the eighth week of anaerobic digestion. The methane production was recorded every week. Maximum methane production was recorded in T5 (54.1/L) as compared to control (41.4/L). There was an increase in biogas (22.4%) and methane (30.9%) production compared to control after eight weeks of batch anaerobic digestion in T5 at the laboratory scale.

Torrefaction System of 200 kg Biomass Loading Capacity

A pilot scale torrefaction system having a 200 kg biomass loading capacity was developed, installed and commissioned in the energy enclave at *ICAR-CIAE, Bhopal* centre. The unit is equipped with six electric heaters of total 9 kW capacity and has pro-vision for the removal of torrefied biomaterial by tilting the reactor. Torrefaction experiments were carried out on paddy straw to investigate the biopolymeric changes in crop residue when the biomaterial was heated to temperatures of 200–300 °C and residence times of 60-180 minutes. The recovery was found to vary from 90 to 98%.

Activated Carbon from Agro-Industrial Wastes

SPRERI, VV Nagar centre produced the activated carbon from agro-industrial wastes. The up-scaled reactor of 5 kg capacity was designed and fabricated. The production of activated carbon was done by the chemical activation method because chemical activation was found to be more economical and effective than physical activation. The experiments were carried out with 250 g char of groundnut shell (GNS), sawdust (SD), and cotton stalk (CS) separately, using $ZnCl_2$, H_3PO_4 and KOH as an activating agent, having (1:1 impregnation ratio) at 550°C temperature and 100 mL/min of nitrogen flow. The yield (wt%) observed is in



the range of 85-90 wt.% for all the selected feed-stalks. Methylene blue number (MB_n) observed for the samples are GNS_$ZnCl_2$ (198.8 mg/g), GNS_H_3PO_4 (195.0 mg/g), GNS_KOH (193.4 mg/g), SD_$ZnCl_2$ (196.2 mg/g) and CS_ $ZnCl_2$ (197.8 mg/g).

CRP ON PRECISION FARMING

Growing Media Sieving, Mixing and Bag Filling Machine

Growing media sieving, mixing, and bag filling are tedious and time-consuming operations. Therefore, a growing media sieve and a mixer-cum-bag filling machine have been developed at ICAR-IIHR, Bengaluru centre, to mechanize these operations. The machine

consists of a sieving unit, a mixing unit, and a bag filling unit. First, the growing media is poured into a hopper, which is fitted with an elevating system. The media from the elevating system is conveyed to the sieving unit having a 10 mm square mesh. Next, the primarily sieved media from the sieving unit is conveyed to the mixing unit. Then the media is uniformly mixed and passed through a square mesh. Finally, the sieved media is conveyed to the bag filling unit. The media is packed in standard seized bags according to the nursery requirement. Ten man-days are required to manually fill one tonne of media, whereas the developed machine can fill 1.5-2.0 tonnes of growing media per hour and can save 60% of man-days.

Tractor Mounted Harvester for Maize and Sorghum

Harvesters suitable for crops like maize, sorghum, pearl millet and other tall and wide-row crops are not widely used due to their in feasibility. Therefore, a small tractor -powered, maize and sorghum harvester has been developed at ICAR-CRIDA, Hyderabad centre. The sorghum harvester cuts sorghum stems without letting the stems fall in a forward direction and windrows the cut stems. The harvester is divided into three parts, i.e. counter-rotating blade assembly, the vertical drum conveyor and the vertical flat conveyor. The harvester consists of a five-crop row divider, a cutting unit, a windrow conveyor, and two-conveying units. The counter-rotating type cutter consists of a circular saw

disc of diameter 0.34 m and thickness of 5 mm. The cylinder rotating speed is 540 rpm. The rotating blade assembly consists of four blades covering 1.28 m width of operation. The tractor's PTO power is transmitted to the sorghum harvester through the universal shaft, gearbox, chain, sprocket set, and accessories.

Hydraulic System Assisted Automatic Basin Lister for Fruit Orchards

The weed biomass cleaning in tree basins and its listing is carried out manually to a larger extent. It provides a better environment for the young plants to grow. A tractor-operated hydraulic carriage frame is developed at ICAR-CRIDA, Hyderabad centre. The machine consists of two components; the first is a hydraulic power

pack fitted over a carriage frame attached to the tractor's three-point hitch system, and the pack gets power from the tractor's PTO shaft. The second component is a toolbar fitted to the tractor chassis in front of the tractor's rear tyres. The carriage frame is rectangular (1.8×0.67 m) and made with mild steel square bar of 50×50×5 mm. The machine is evaluated in a mango orchard (15 years of age) at 0.42 m/s speed of operation and 1250 rpm of weed biomass trimming speed. The developed machine facilitates a better environment for the younger plants to grow.

Autonomous Platform for Weed Removal in Raised Bed

ICAR-CRIDA, Hyderabad, centre of CRP on PF, has developed a four-wheel drive platform for mounting weed detection sensors, actuators, and weeding tools for removing weeds from raised bed planting systems. A platform with a steering wheel has been developed. The

platform is semi-automatic and equipped with sensors to help it understand its surroundings and navigate around the field for various tasks. Two ultrasonic sensors are mounted on each platform's front steering wheel, which detect the distance between the machine and the obstacles in front of it. This is mostly used to identify the field's end and take a turn. In addition, each front steering wheel has a 9-axis gyroscope that provides information on varied forces operating on the wheels due to uneven terrain and to sense wheel orientations. An identical gyroscope is installed in the platform's centre to detect the platform's overall position and orientation in the field. All the sensors, as mentioned above, send data to a controller, which provides instructions to the driving and steering wheels, allowing them to move and navigate efficiently. The new developments help carry out the weeding and spraying operations in small land holdings.

Self-Propelled Tomato Harvester

Tomato is one of the major vegetable crops grown in Karnataka State, which needs 10-15 harvests in each crop cycle and requires about 1-2 man-days/acre. An autonomous tomato harvester has been designed and developed at ICAR-IIHR, Bangalore centre, based on relevant physical parameters of the tomato crop. It consists of a combing mechanism, collection box, a DC motor, batteries and accessories. This mechanism has been fitted at the base of the main frame connected to the driving wheels and combing mechanism through a suitably designed gear and belt pulley mechanism. There all horizontal rotary rollers, vertically reciprocating rollers, and vertical rotary roller mechanisms. The mounting height of the roller is 0.46 m and 1.2 m in the first two mechanisms. In the third mechanism, the frame has a stroke length of 0.18 m. The pegs are welded on the roller in a zig-zag manner. The peg diameter and length are 0.01 m and 0.26 m, respectively. The coverage height of the mechanisms is 1.8 m. Polypropylene (PP) sleeves are provided for the pegs in order to reduce mechanical damage.

Horizontal roller type

Vertically reciprocating roller type

Vertical rotary roller type

CRP ON ENERGY FROM AGRICULTURE

Refinement of Bio-oil Based Burner for Thermal Application

The SPRERI, VV Nagar Centre has developed a burner assembly to utilize bio-oil and its blends with furnace oil. Refinement of the burner is carried out in such a way that the large-scale industrial fuel can be utilized. During the combustion trial, up to 20 wt % bio-oil in the blends has

shown the stable performance of the burner in terms of flame profile and flame temperature. The emission study shows that, with the increasing equivalence ratio, the CO emission reduces. On the other hand, the NO emission increased with increasing bio-oil content in the furnace oil due to the higher temperature in the combustion chamber and availability of excess oxygen. In addition, the particulate matter emission increased with bio-oil due to high SPM content and its polymerization effect.

Activated Biochar Production System from Crop Residues

The MPUAT, Udaipur centre, has developed an activated biochar production system with a capacity of 1-5 kg biomass. *Prosopis juliflora* biomass showed a higher biochar yield of 36.5%, followed by coconut shell and

wheat straw at a residence time of 100-120 min under reduced pressure of 15-20 kPa. The biochar was activated using an impregnation technique for making activated biochar. Among all activated biochar samples, wheat straw activated biochar was found superior in terms of its physicochemical composition. Therefore, the contaminants sorption capacity of wheat straw activated biochar was assessed for open well and filtered water in a developed activated biochar-based water filtration system. The results showed that the pH, EC, TSS, BOD, COD, O & G, and TDS were found to be lower in filtered water than in initial open well water.

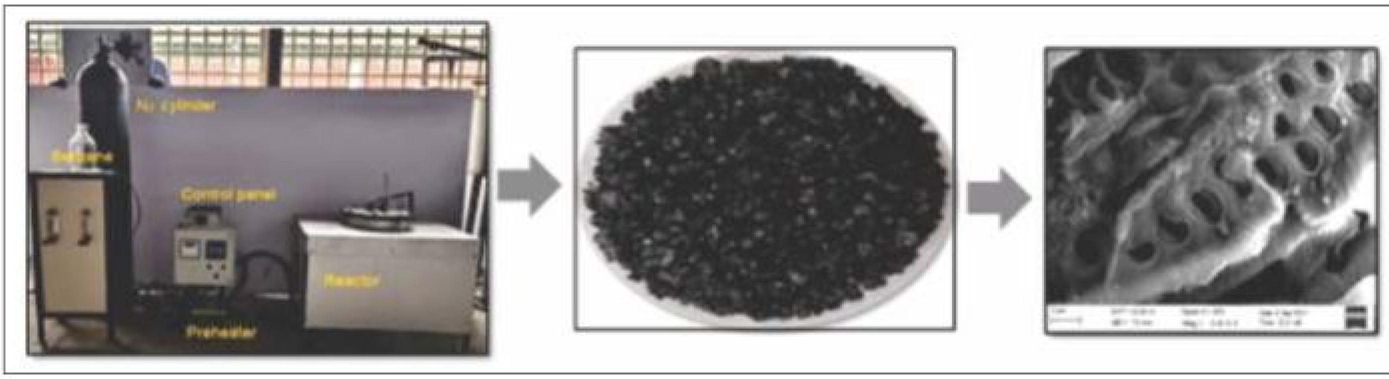
Nanocomposites from NADES Extracted Lignin

SPRERI, VV Nagar selected different agro-residues viz. cotton stalk, sawdust, sugarcane bagasse, rice straw, and wheat straw for lignin extraction. Lignin extracted from agro-residues using a NADES-based process was subjected to nanoparticle synthesis. The methods employed for nanoparticle synthesis through lignin were anti-solvent and dialysis method. The Smallest nanoparticle of 73 nm was obtained through the rice straw lignin from the dialysis method. The nanoparticles

synthesized were characterized thoroughly using different analytical techniques. Further, the lignin nanoparticles were utilized for synthesizing nano-gels using acrylamide, bis-acrylamide and irgacure through the UV curing process. Finally, the synthesized nano-gels were characterized and applied for water absorption studies, where nano-gels were found to have almost 8 times higher water retention capacity as compared to hydro-gels.

System for Production of Carbon Molecular Sieves from Lignocellulosic Biomass

TNAU, Coimbatore, has developed a system for the production of carbon molecular sieves from selected



lignocellulosic biomass. Maize cob and cotton stalk were selected as precursors for carbon molecular sieve production. A lab-scale carbon molecular sieve reactor of 1 kg capacity with a diameter of 120 mm, a height of 340 mm and a thickness of 4 mm was developed for both chemical activation and chemical vapour deposition process. Phosphoric acid was the efficient dehydrating agent in producing activated carbon with a higher iodine value (1602 mg/g) and yield (33.7%). The carbon molecular sieve prepared at this optimized condition showed a surface area of 1607 m^2/g with a micropore volume of 0.5931 cm^3/g. The CO_2 adsorption capacity of 355.8 mg/g was achieved using the developed carbon molecular sieves.

Paddy Straw-Based Biogas Plant

PAU, Ludhiana, constructed and installed the paddy straw-based biogas plant at Gurdwara Karamsar Rara Sahib, District – Ludhiana. The paddy straw-based biogas plant is made of mild steel sheet and can hold 100 MT of paddy straw per batch. The plant was commissioned in November 2021. The installed plant has the capability to utilize the paddy straw collected from an area of 20 hectares.

Construction of pit for placing M. S. Gas holder

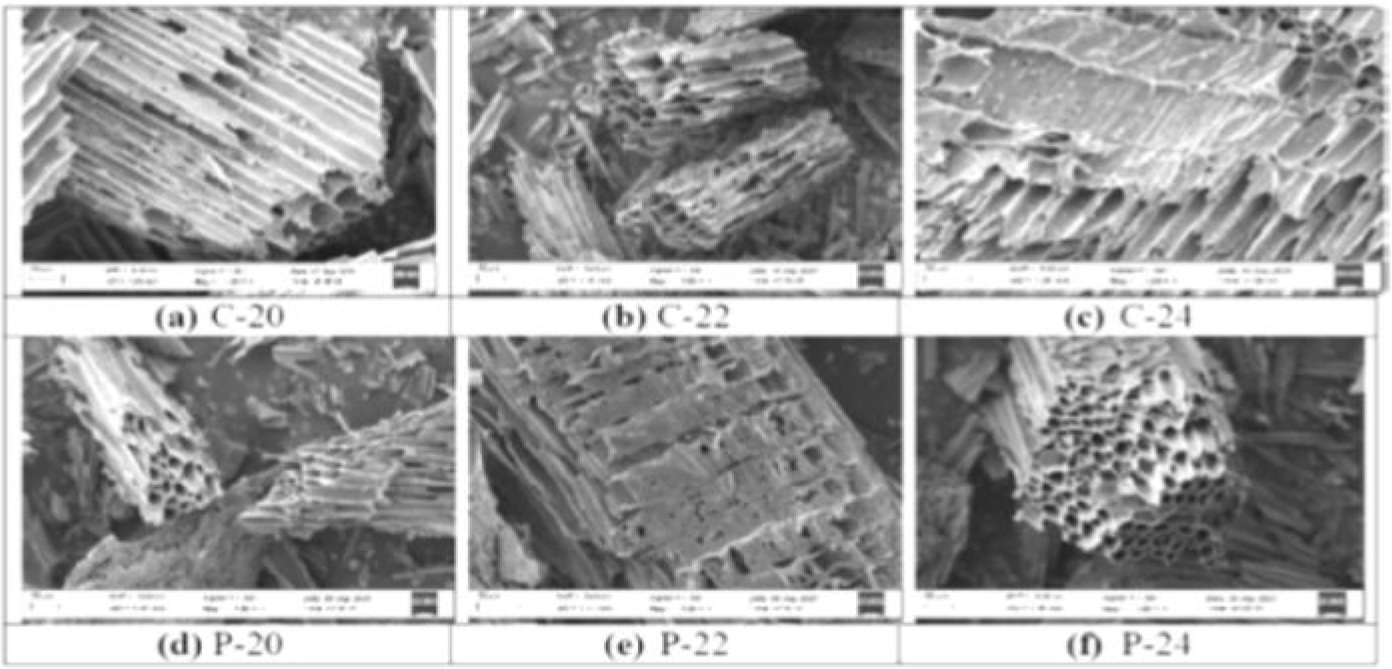
Fixing of guide frame for placing M. S. Gas holder

Placing M. S. Gas holder

Overall view of biogas plant

Biochar from Gasification of Castor/Pigeon Pea Crop Residues

The JAU, Junagadh optimised process for making biochar using an open core throat less down draft biomass gasifier from castor and pigeon pea crop residues. The highest values of residual biochar production were found to be 22.02 and 22.41% at gas flow rates of 22 m^3/ h for shredded castor and pigeon pea stalk, respectively. The SEM analysis indicated a highly porous structure of biochar, which can be used for stripping ions, heavy metals, dyes, and other organic and inorganic contaminants from water and wastewater. FTIR results confirmed that the aromatic C=C stretching in char might be possible due to depolymerisation and complete decomposition of biomass at a higher gas flow rate. In addition, functional groups such as aromatic, hydroxyl, phenolic, aliphatic ester, aliphatic, alkane, carbonate, and carboxyl were found to be present in biochar samples.



TECHNOLOGY TRANSFER

Technology Commercialization:

The technologies developed by the institute are being promoted by involving farm, and processing machinery manufacturing and food processing industries through licensing. During the year 2021-22, the institute had signed license agreement with 16 industries to promote 21 CIAE technologies.

ICAR-CIAE Manual Cono Weeder

- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh

ICAR-CIAE Pedal Cum Power Operated Grain Cleaner Cum Grader

- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh

ICAR-CIAE Pedal Operated Potato Peeler

- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh

ICAR-CIAE Pedal Operated Potato Slicer

- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh

ICAR-CIAE Multipurpose Mini Grain Mill

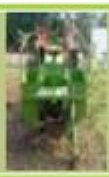
- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh
- M/s Swastik Agro Industries, Rajnandgaon, Chattishgarh

ICAR-CIAE Multipurpose Dal Mill

- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh
- M/s Swastik Agro Industries, Rajnandgaon, Chattishgarh

ICAR-CIAE Manual Peg Type Dry Land Weeder

- M/s Laxmi Steel Fab, Sehore, Madhya Pradesh



ICAR-CIAE Tractor Operated Cassava Stake Cutter Planter

- M/s Bhansali Agro Tech., Ahmednagar, Maharashtra

ICAR-CIAE Tractor Operated Cassava Harvester cum Lifter

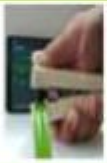
- M/s Bhansali Agro Tech., Ahmednagar, Maharashtra

ICAR-CIAE Sugarcane rind removing equipment for juice making

- M/s Celebrating Farmers Edge International Pvt Ltd, Nashik, Maharashtra

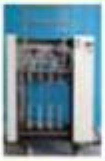
ICAR-CIAE-NRCB Banana Pseudostem Injector

- M/s Magnificent Engineers, Coimbatore, Tamil Nadu



ICAR-CIAE SPAD Meter

- M/s SKR AGROTECH., Wardha, Maharashtra
- M/s Next Gen, Nagpur, Maharashtra



ICAR-CIAE-NRCB Mechanized Package for Rope making from outer sheath of Banana Pseudostem

- M/s Trytex Machine Company, Coimbatore, Tamil Nadu

ICAR-CIAE Modular Backyard Poultry Cage

- M/s Burgeon Agri Pvt Ltd., Nashik, Maharashtra

Software for capturing shape and size features of plant parts

- M/s ICAR-NBPGR, Pusa, New Delhi

ICAR-CIAE-SBI Sugarcane sett treatment device

- M/s Amit Agro Associates, Rampur, Uttar Pradesh

ICAR-CIAE-SBI motorized double headed sugarcane single bud cutting machine

- M/s Sri Balaji Industries, Coimbatore, Tamil Nadu

ICAR-CIAE Anola deseeding/ segmentation unit

- M/s Sri Balaji Industries, Coimbatore, Tamil Nadu

ICAR-CIAE Process Technology for Soya Chaap

- M/s Khiyansh Dairy Delight, Gurugram, Haryana
- M/s Neha Kumari from Patna, Bihar

ICAR-CIAE Modular Onion Storage Structure

- M/s GV Industries, Dhar, Madhya Pradesh

ICAR-CIAE Manual Palmyra Endosperm Remover

- M/s Hydro Kraft Technologies, Coimbatore

Commercialization of Technologies 2021-22

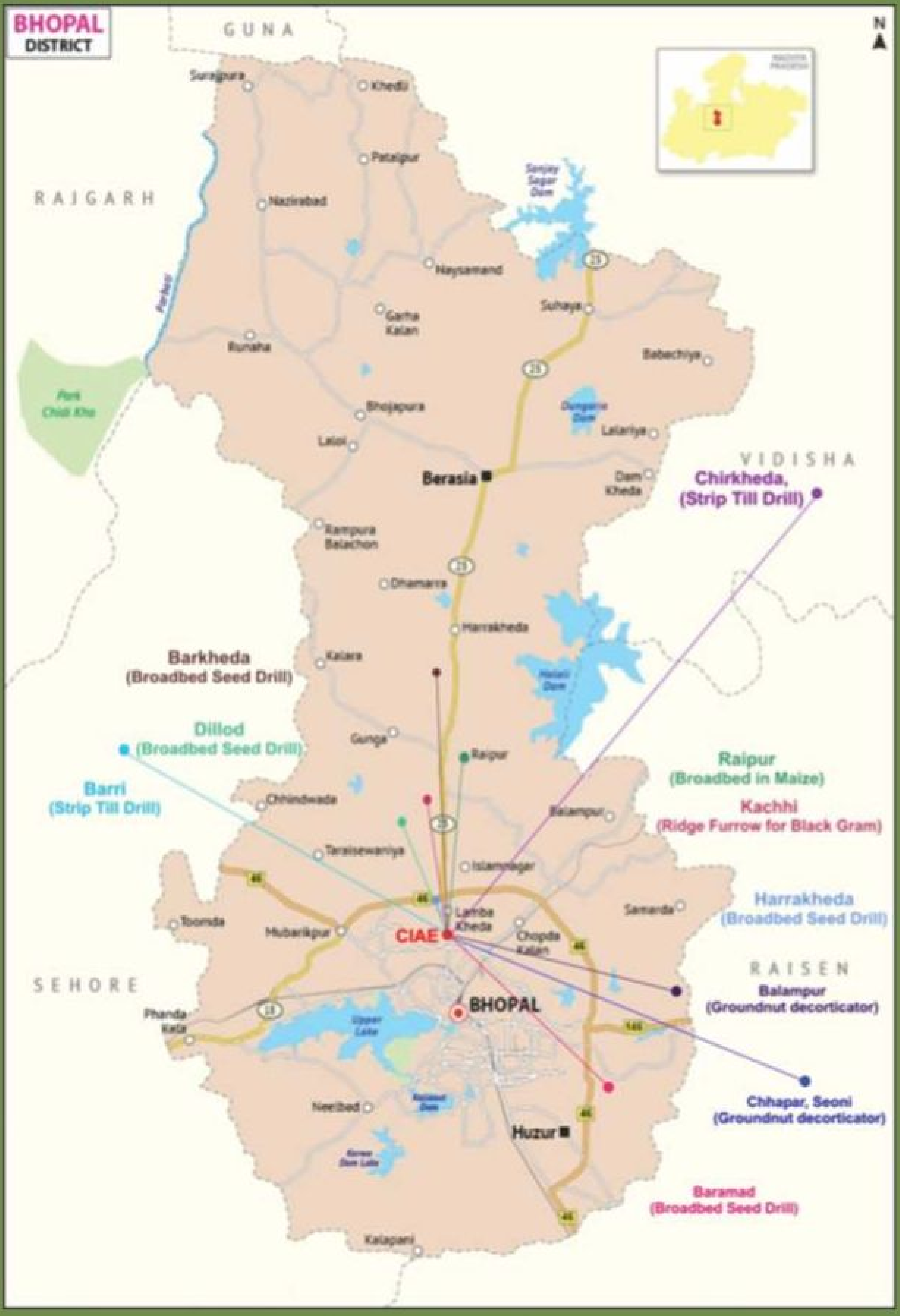
Newly Released Technologies

S. No.	Name of Technology	Name of Scientist	QR CODE
1	Lightweight Multi-Crop Thresher foHills	Sweeti Kumari K P Singh Shyam Nath	
2	Fruit - Vegetable Postharvest Treatment Machine	S K Chakraborty	
3	Process Technology for Dietary Fibre Extraction	Ajesh Kumar V S Mangaraj Muzaffar Hassan	
4	Solar Assisted E-Prime Mover for Spraying, Weeding And Allied Works	P C Jena	
5	Tractor Operated Tobacco Seedling Transplanter with Spot Applicaton of Water	T Senthilkumar M Anuradha, ICAR-CTRI, RS Kandukur	
6	Mini Tractor Operated EPN Applicator for Sugarcane White Grub Management	T Senthilkumar Syed Imran S T Arumuganathan, ICAR-SBI, Coimbatore C Sankaranarayanan, ICAR-SBI, Coimbatore	
7	Power Operated Multiplier Onion Grader	Dawn C P Ambrose	
8	Cleaner For Multiplier Onion	Dawn C P Ambrose	

S. No.	Name of Technology	Name of Scientist	QR CODE
9	Soybean Aqueous Extract Based Edible Film	Ajesh Kumar V S Mangaraj Muzaffar Hassan	
10	Improved Millet Mill	S Balasubramanian	
11	Quinoa Pearler	S K Aleksha Kudos S Balasubramanian	
12	Annular Core Biochar Production System	Sandip Gangil Vinod K Bhargav	
13	Tubular Condenser Integrated Bio Oil Unit	Sandip Gangil Vinod K Bhargav Sandip Mandal	
14	Portable Rotating Charring Kiln	Sandip Mandal	

On-Farm Trials/ Demonstration at Farmer's Field by KVK-CIAE

S. No.	Name of the Equipment/ Technology	No. of demonstrations conducted	Area covered in ha or hours of use	No. of farmers/ users familiarized
1	Manual seed drill	03	0.6 ha	120
2	Pull type manual transplanter	02	0.3 ha	155
3	Battery operated sprayer	08	27 ha	150
4	Manually guided power weeder	10	36 ha	200
5	Wheel hoe	04	2.4 ha	40
6	Maize sheller	04	5 h	40
7	Sugarcane detrasher	06	2.5 h	60
8	Power operated sugarcane bud chipper	02	8 h	35
9	Multi millet thresher	08	23 h	110
10	Root vegetable washer	04	25 h	120
	Total	51		



Demonstration of CIAE-Agricultural implements by KVK, CIAE

Cluster Frontline Demonstration in Oilseed Crop (JS 2034)

Demonstration of Broad Bed Seed Drill Machine in Maize crop

Cluster Frontline Demonstration in Pulses Crop (RVG-202)

Demonstration of Semiautomatic Potato Planter at Farmers field

Demonstration of Groundnut Decorticator

Participation

S. No.	Topic	Date	Village	No. of participant
1.	Use in Farm Machinery in Rabi Crop Production	15-03-2021	Village Arjun khedi, Block Berasia,	25
2.	Krisak Sangosthi on Agricultural machinery in collaboration with ATMA	19-03-2021	Berasia Block	44
3.	Farmers Scientist Interaction	25-03-2021	Sarvar (Phanda)	23
4.	"Farmers Scientist Interaction" Programme on the Vermicompost production	19-08-2021	Barkhedi Abdulla (Phanda) Bhopal	05
5.	Krishak Sanghoshthi organised by ATMA, Bhopal	24-09-2021	Ratanpur Block Phanda Bhopal	20
6.	Krishak Sanghoshthi organised by ATMA, Bhopal.	26-10-2021	Dugariya Block Berasia Bhopal	20
7.	Krishak Sangosthi under "Swacchata Abhiyan" on Agriculture Waste Management jointly organised by ICAR-CIAE KVK Bhopal and ATMA Bhopal	26-11-2021	ICAR-CIAE, Bhopal	86
Total				**223**

TV talks

Name and designation of the presenter	Subject	Name of the program/Media	Date
Dr. Dilip Jat, Scientist	कटाई गहाई के उन्नत कृषि यन्त्र	Krishi Darshan DD, MP	22-02-2021
Er. D K Dwivedi CTO, KVK	Use of Potato Digger in potato cultivation	ETV, Bhopal	10-03-2021
Er. D K Dwivedi, CTO, KVK	Importance of deep summer ploughing in field for higher production of crop	ETV, Bhopal	30-03-2021
Dr. K V R Rao, Principal Scientist	Micro Irrigation Systems Maintenance	DD, Bhopal	24-08-2021
Dr. T Senthilkumar, Principal Scientist	Tractor operated two row settling transplanter for sugarcane seedlings raised in portrays	Makkal TV (Tamil TV channel)	31-08-2021
Dr. K V R Rao, Principal Scientist	Protected Cultivation	DD, Bhopal	07-09-2021
Dr. Dilip Jat, Scientist	कटाई गहाई के उन्नत कृषि यन्त्र	Krishi Darshan program of Doordarshan, MP	20-09-2021
Dr. T Senthilkumar, Principal Scientist	Tractor operated two row settling transplanter for sugarcane seedlings raised in portrays'	BBC News Tamil	06-10-2021

TRAINING AND CAPACITY BUIDLING

National training

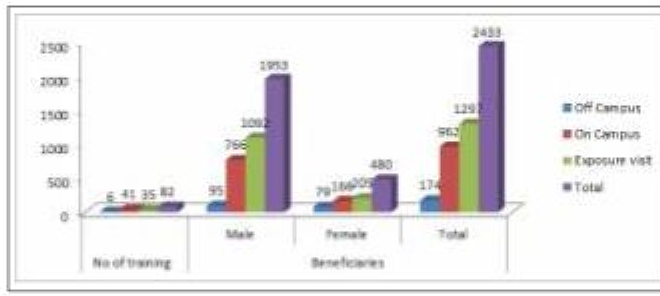
A 21 days Winter School on "Farm Mechanization for Facilitating Conservation Agriculture & Climate Smart Technology Adoption" was organized during January

04-24, 2022. A total of 14 participants from different institutes /universities / KVKs participated in this training course of 21 days, which was aimed to develop human resource, capable of addressing mechanization needs for promotion and adoption of engineering technologies in Conservation Agriculture and Climate Smart Farming.

Other training programs

Trainings organized by KVK

KVK organised training programme in hybrid mode (virtual and physical) for the farmers, farm women and extension personnel.



DST Capacity Building-cum-Demo

S.No.	Programme details	Date	District	Beneficiaries
1	Women Friendly Machinery Demo	25.08.2021	Karumanthurai, Salem	45
2	Women Friendly Machinery Demo (Root Vegetable Washer, Battery sprayer and power weeder)	01.10.2021	Karumanthurai, Salem	40
3	Manual Transplanter Demo	30.08.2021	Coimbatore	12
4	Women Friendly Machinery Demo (Multi -Millet Thresher)	23.10.2021	Thalavdi, Erode	
5	Women Friendly Machinery Demo (Multi-Millet Thresher, Battery sprayer and power weeder)	11.02.2022 12.02.2022	Thalavdi, Erode Karumanthurai, Salem	65
6	Field Day cum Demo	15.02.2022	Thalavdi, Erode	30

Soy-food Training program for Upcoming Entrepreneurs

The Centre of Excellence on Soybean Processing and Utilization (CESPU) conducted four soy-food training programs for upcoming entrepreneurs in 2021. The training's main goal was to develop soy-based food enterprises that can produce high-quality protein and other nutrient-rich food products at a low cost and create livelihood opportunities and employment generation. Participants were provided with technical guidance and additional support required for establishing soy-based entrepreneurship. Forty-two people were imparted training during February 15–20, 2021; 2–7, August 2021; 25–30, October 2021; and 13–18, December 2021 under these programs.

Training on Machinery for onion cultivation & processing under CRP on FM&PF

ICAR-CIAE Regional Centre Coimbatore and ICAR-IIHR, Bengaluru jointly organised a demonstration cum training program on 'Machinery for onion cultivation & processing' for the benefit of onion growers of Coimbatore district on 24.07.2021 at Covai Kalaimagal College, Narasipuram, Coimbatore under CRP on Farm Mechanization and Precision Farming project. Dr. T Senthilkumar, Principal Scientist, ICAR-CIAE Regional Centre enumerated the importance of the program and welcomed the gathering. Dr. Babu Vinoth Kumar, Principal, Covai Kalaimagal institute of management emphasized the need for onion machinery to reduce the drudgery and cost of cultivation during his special address. Dr. S Balasubramanian, Principal Scientist & Head, ICAR-CIAE Regional Centre elaborated the mechanization and automation towards in agricultural operations in general, horticultural crops in particular. He highlighted the list of various packages of machinery designed and developed at ICAR-CIAE Regional Centre for sugarcane, banana, carrot and cassava during his presidential address. Dr. A Carolin Rathinakumari, Principal Scientist, ICAR-IIHR, illustrated the small onion on-farm processing machineries viz., onion detopping & onion cleaner and its usefulness in reducing the drudgery and time consumption. Dr. Dawn CP Ambrose, Principal Scientist, ICAR-CIAE Regional Centre demonstrated the package of machinery for post-harvest operations of onion crop. Dr. Saraswathi Easwaran, Secretary, RCT, Coimbatore delivered a lecture on onion value addition. Mrs. S Revathi, a progressive farmer of Narasipuram village shared her success story by adopting the ICAR-IIHR Arka onion detopper. During this program equipment viz., IIHR-Manually operated onion seeder, IIHR Arka onion detopper, CIAE-Manually operated onion grader, CIAE-Power operated onion grader and CIAE-Power operated onion cleaner was demonstrated to the farmers. About 75 onion growing farmers participated in this one-day demonstration cum training program. The training program ended with vote of thanks by Dr Syed Imran, ICAR-CIAE Regional Centre. The program was coordinated by Dr. T Senthilkumar, Principal Scientist of this centre under CRP on Farm Mechanization and Precision Farming project.

Training on Machinery for onion cultivation 4 processing under CRP on FM&PF

Mera Gaon Mera Gaurav activities

ICAR-CIAE Regional Centre, Coimbatore celebrated WORLD WATER DAY-2021 in the theme of 'VALUING WATER' at Yelur village (MGMG village), Madhukarai block, Coimbatore district on 22.03.2021 in collaboration with ICAR-Indian Institute of Soil and Water Conservation Regional Centre (Ooty, TN), leading manufacturers of drip/rain hose, and farm machinery. About eighty-five farmers (men & women) participated in this program. During his special address, Dr. S Balasubramanian, Principal Scientist & Head, ICAR-CIAE Regional Centre, detailed about the theme of world water day and he emphasized the farmers to adopt recent technologies to conserve moisture and save water. Dr. T Senthilkumar, Principal Scientist explained about the insitu rain water harvesting measures in the field to conserve water. Followed by these talks, a farmers discussion forum was held to understand about these techniques adoption to harness the real benefits in their specific field situation. A participatory field demonstration viz., (i) Irrigation water saving kits (rain/drip hose) for modern drip system M/s. KSNM Marketing, Coimbatore, (ii) Tractor operated mulch-cum-drip lateral laying machine by M/s. Magnificent Engineers, Coimbatore was conducted at the contact farmer's vegetable growing field. Also, the farmers were provided with AV aids and relevant literatures in bilingual form. The program was started with welcome of gathering by Dr. S Syed Imran and ended with vote of Thanks by Dr. M Mohan, Asst. Chief Technical Officer. The program was coordinated by Dr. Ravindra Naik & Dr. T Senthilkumar, Principal Scientists of this centre.

Demonstration of Tractor operated raised bed former cum onion set planter for multiplier onion (small onion) to farmers of MGMG village at *Yelur* village, Madhurkarai block, Coimbatore district Tamil Nadu

ICAR-CIAE Regional Centre demonstrated Tractor operated raised bed former cum onion set planter for multiplier onion (small onion) to farmers of MGMG village at Yelur village, Madhurkarai block, Coimbatore district Tamil Nadu on 27.01.2022. Dr. T Senthilkumar, Principal Scientist and Dr. Syed Imran, S, Scientist, ICAR-CIAE Regional Centre, Coimbatore field-demonstrated the tractor operated raised bed former cum onion set planter for multiplier onion and explained about its operation and its maintenance.

During the demonstration Dr. S Balasubramanian, Principal Scientist and Head, ICAR-CIAE, Regional Centre, Coimbatore and Th Rangaraj, Leading farmer, Yelur village were also present. More than 15 leading onion growing farmers from MGMG adopted village group were benefited by the demonstration.

SCSP Activities

A "Central Sector Scheme of Special Central Assistance (SCA) to Scheduled Castes Sub Plan (SCSP)" has been implemented by the Government of India for the development and improvement of the living status of the Scheduled Castes community, who form the major chunk of the country's population living below poverty line (BPL). A project titled "Technology Outreach and Agricultural Engineering Interventions for Improving the Rural Livelihoods of SC BPL beneficiary of selected villages of Madhya Pradesh and Tamil Nadu" is undergoing at the institute under the SCSP component scheme.

The main objectives of the project are to identify the SC-BPL beneficiaries of rural villages of Madhya Pradesh and Tamil Nadu, identify their critical gaps/needs and perform different activities for their livelihood support and income generation. Accordingly total 13 number of villages (Ujjain district, 05: Kadacha, Shilarkhedi, Chenpur, Khemasa, Buchakhedi; Bhopal district, 05: Kanera, Raipur, Kardai, Guradiya, Nipaniya Sukha and Tamil Nadu, 03: Navalur, Melapuliyur, Bellapalayam-Vedar) with 383 families have been selected, and different project activities have been performed for the benefit of the SC-BPL beneficiaries of selected villages.

Various training/capacity building and demonstration cum distribution programmes were organized for the livelihood support and upliftment of living standards of the beneficiaries. The programmes were organized mainly on agricultural engineering aspects viz., "Practical training of farmers on agricultural machinery, soya processing, renewable energy and water management", "Practical training of women on agricultural product processing and soyabean processing"; and skill development in repair, maintenance and operation of agricultural tools/ equipment and machinery, along with some field days and demonstration cum distribution programmes. A total 39 number of programmes were organized from January to December 2021, benefiting a total 1294 number of beneficiaries. The participants were sensitized to various Agricultural Engineering technologies, including farm machinery, food processing, energy and irrigation aspects, highlighting the benefits of the use of technologies and use these technologies for livelihood support and income generation.

Livelihood support through Direct Benefit Transfer (DBT) by the distribution of agricultural inputs and equipment is also one of the activities of the SCSP programme. Accordingly, 20.25 tonnes of fertilizer (DAP) and 78-litre chemicals (herbicides, pesticides) were distributed to the selected beneficiaries, who were involved in the farming occupation. Various ICAR-CIAE developed technologies, especially hand tools/equipment and some food processing enterprise development-related equipment were demonstrated and distributed to the identified beneficiaries of selected villages through various demonstration cum distribution programmes. A total 2553 number of tools/equipment was distributed to the identified beneficiaries. The distributed items

Total number of adopted villages	13
Total no of beneficiaries	1294
No. of programs conducted	39
Direct Benefit Transfer (DBT)	
Equipment	2553
Fertilizer (DAP)	20.25 tonnes
Herbicides & pesticides	78 litre
Implements provided to SCSP beneficiaries	
Manually operated weeders, ridger, planter, maize sheller, hoe, sickle, groundnut decorticator, crowbar, digging fork, sprayers, irrigation pipes, solar study lamp, dust bin, water tank, watering can for plants	

include CIAE-developed farm tools/equipment such as manually operated weeders, ridger, planter, maize sheller, hoe, sickle, groundnut decorticator, crowbar, digging fork, sprayers, irrigation pipe, and some domestic items such as solar study lamp, dust bin, water tank, watering can for plants. All the distributed items were demonstrated, and the beneficiaries were sensitized to the importance of this equipment for their livelihood support, enterprise development and income generation. The project is fruitful to the SC-BPL beneficiaries of rural villages by means of knowledge generation, increased awareness and enterprise development on Agricultural and allied activities and support to their livelihood through direct benefit transfer (DBT) of agricultural input and equipment.

SCSP Trainings

S No.	Programme details	Date	District	Beneficiaries
1	Capacity building program on Advanced Machinery for Maize, Onion and Groundnut Crops for Melapuliyur Village & Navalur Villages	01-10-2021	Perambalur (Tamil Nadu)	100
2	Capacity building program on promotion of CIAE technologies for rural entrepreneurship for bellapalayam and vedar colony	26-11-2021	Coimbatore (Tamil Nadu)	30
3	Field day cum demo and distribution programme of tools/equipment sprayers and fertilizers for Melapuliyur and Navalur villages	16-12-2021 17-12-2021	Perambalur (Tamil Nadu)	228
4	Capacity building program on women friendly technologies for Maize, Onion and Groundnut crops for Irumporai and Pethikuttai villages	23-12-2021	Coimbatore (Tamil Nadu)	34
5	Capacity building program on operation and maintenance of Maize, Onion and Groundnut crop machineries and Fertilizer distribution for melapuliyur & Navalur Villages	31-12-2021	Perambalur (Tamil Nadu)	66
6	Field day cum demo and distribution programme of tools/equipment and sprayers for Melapuliyur and Navalur villages	01-01-2022	Perambalur (Tamil Nadu)	14

Human Resource Development

Name & Designation	Training Title (Virtual Mode)	Duration	Organized by
Swapnaja Jadhav, Scientist	Environmental practices and renewable energy utilization	05-14 Jan, 2021	Dr PDKV, Akola
Manoj K. Tripathi, Principal Scientist	Enhancing research skills and refinement of technology by a scientist	18-20 Jan, 2021	ICAR-IIHR, Bangalore
Subeesh A, Scientist	Cyber security	21 Jan, 2021	Ministry of Electronics and Information Technology, Govt. of India
Subir Kumar Chakraborty, Principal Scientist	Data visualization for agribusiness and agricultural research	22-27 Feb, 2021	ICAR-NAARM, Hyderabad
Satya Prakash Kumar Scientist	Fundamentals of UAVs	15 Mar-04 Apr, 2021	ICAR-NAHEP, MPKV Rahuri
Adinath Kate, Scientist	Characterization of Food and Beverages Through Tribology, Rheology, and other Techniques	25 May, 2021	IIPM, Bengaluru and Anton Paar India Pvt. Ltd
Ashutosh Pandirwar, Scientist	Rapid Prototyping and Reverse Engineering by 3D Scanner and 3D Printer in Agriculture	07-18 Jun, 2021	NAHEP Centre of Excellence, VNMKV, Parbhani
Adinath Kate, Scientist Chirag Maheshwari, Scientist	Onion Processing and Value addition	11 Jun, 2021	NIFTEM, Thanjavur
Ravindra Naik, Principal Scientist	Management Development Programme on Business Plan Development and Accelerating FPOs/FPCs	21-26 Jun, 2021	ICAR-NAARM, Hyderabad
Punit Chandra, Principal Scientist	Standardization, BIS	22-23 Jun, 2021	National Institute of Training for Standardization (BIS), Noida
Shashi Rawat, Principal Scientist	Programming of Web & Mobile applications using Low-code Platforms	07-12 Jul, 2021	ICAR-NAARM, Hyderabad
Bikram Jyoti, Scientist	Machine learning and AI	19-30 Jul, 2021	IIT Hyderabad and Exulabs
Dilip A. Pawar, Scientist	Ergonomic Design Guidelines for Agricultural Tools and Equipment	26-30 Jul, 2021	AICRP on ESA ICAR-CIAE, Bhopal
Prakash Chandra Jena, Scientist	Artificial intelligence in the energy sector: opportunities and challenge	09-13 Aug, 2021	Gyan Ganga Institute of Technology and Science, Jabalpur
Saroj Kumar Giri, Principal Scientist	Training Workshop for Vigilance Officers of ICAR Institutes	16-18 Aug, 2021	ICAR-NAARM, Hyderabad
Ajesh Kumar V, Scientist Pravitha M, Scientist	Response Surface Methodology	24-28 Aug, 2021	ICAR-NAARM, Hyderabad
Prakash C Jena Scientist	Electric Vehicles: Design to Product Devebpment	01-05 Sept, 2021	A. P. Shah Institute of Technology, Thane
D K Dwivedi CTO	E-Governance in ICAR	06-10 Sept, 2021	ICAR-IASRI, New Delhi
Deepak Singh, Principal Scientist	Biosecurity & Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Isues	15-24 Sept, 2021	ICAR-NBPGR , New Delhi

Pravitha M, Scientist	Recent trends in non-thermal food processing: Prospects and Challenges	04-08 Oct, 2021	IIFPT, Thanjavur
Pravitha M, Scientist	Training Programme on Internet of Things (IoT)	25-29 Oct, 2021	Ministry of Science & Technology, Govt of India
Sweeti Kumari, Scientist	Mechanized weed management in different field crops	01-03 Nov, 2021	ICAR -DWR, Jabalpur
S. Balasubramanian, Principal Scientist	Advances in web and mobile application development	06-10 Dec, 2021	ICAR-NAARM, Hyderabad
Shashi Rawat, Principal Scientist	Development Programme on Leadership Development	13-24 Dec, 2021	ICAR-NAARM, Hyderabad

PhD Awarded to Staff

	Name and Designation	University	Thesis title	Date of award
	Deepika Shende Channe, Technical officer	IIT, Kharagpur	Development of Refractance Window Drying Protocol for Production of Intermediate Moisture Mango Leather	23-01-2021
	Chirag Maheshwari, Scientist	IARI, New Delhi	Impact of Ribulose-1, 5-bisphosphate carboxy lase/oxygenase-(RUBISCO) knockdown on photo synthesis-and growth characteristics of rice plants	27-01-2021
	Satya Prakash Kumar, Scientist	IIT Kharagpur	Design and development of a tractor operated sensor based inter and intra row weeder for wider row crops	23-06-2021
	Manish Kumar, Scientist	CIAE-IARI	Studies on Spray Characteristics of Selected Nozzles with Bio-Pesticides	07-12-2021

AWARDS AND RECOGNITION


Indian Council of Agricultural Research
National Award of Excellence for Agricultural Institutions
SARDAR PATEL OUTSTANDING ICAR INSTITUTION AWARD 2020
(Large Institute)
is presented to
ICAR-Central Institute of Agricultural Engineering, Bhopal
16 July, 2021
New Delhi

ICAR-CIAE conferred with Sardar Patel Outstanding ICAR Institution Award 2020


INDIAN COUNCIL OF AGRICULTURAL RESEARCH
CHAUDHARY DEVI LAL OUTSTANDING ALL INDIA COORDINATED RESEARCH PROJECT AWARD-2018
CITATION

ICAR Chaudhary Devi Lal Outstanding AICRP award

NAAS Recognition Award for Dr. C R Mehta, Director CIAE

NAAS Associate for the year 2021 w.e.f. 1 January 2021.

Dr. Sandip Mandal,
Senior Scientist

Winner of NTPC Green Charcoal Hackathon-2021 in Category-1 plant

II Prize on Oral presentation in Madhya Pradesh Vigyan Sammelan-2021 organized by IIT Indore, MPCST and Vigyan Bharati.

Dr. Bikram Jyoti, Scientist | Er. Jagjit Singh, PhD Scholar
II prize of ₹ 3.00 lakh in hackathon 'Kritgaya' organized by NAHEP and ICAR

ISAE Awards

The Institute Scientists received following awards during 55th Annual Convention of ISAE, organized by Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar during 23-25 November, 2021

ISAE Fellow 2020

Dr. Ravindra Naik, Principal Scientist

Dr. Sukhdev Mangaraj, Principal Scientist

ISAE Commendation Medal 2020

Dr. Saroj Kumar Giri, Principal Scientist

Dr. Krishna Pratap Singh, Principal Scientist

ISAE Team Award 2020

Dr. SK Chakraborty, Principal Scientist
Dr. S K Giri, Principal Scientist
Dr. A Kate, Scientist
Dr. D A Pawar, Scientist
Dr. M K Tripathi, Principal Scientist

ISAE JAE Best Paper Award 2020
Dr. Manish Kumar | Dr.C R Mehta, Director | Dr. K N Agarwal, Principal Scientist
Dr. V K Bhargav, Principal Scientist | Dr. V Bhusana Babu, scientist SS

Best paper presentation awards
Dr. D Jat, Scientist | Dr. D A Pawar, Scientist | Dr. Mukesh Kumar, Scientist | Dr. N S Chandel, Scientist
Dr. P C Jena, Scientist | Dr. S K Chakraborty, Principal Scientist | Dr. Y A Rajwade, Scientist
Er. S M Mansuri, Research Scholar

ISAE JAE Best Reviewer Award 2020
Dr. Balaji M Nandede, Scientist

Best Short Oral Presentation Award in International Conference organized by ICAR-SBI Coimbatore
Dr. Ravindra Naik, Principal Scientist

Best Researcher Award by VDGOOD Professional Association, Villupuram (T.N.)
Dr. R K Singh, Principal Scientist

Special appreciation award 2021 by Institution of Engineers, Coimbatore Centre
Dr. T Senthilkumar, Principal Scientist

I Prize on Oral presentation in Madhya Pradesh Vigyan Sammelan-2021
organized by IIT Indore, MPCST and Vigyan Bharati
Dr. P C Jena, Scientist

Best Paper award by the College of Technology and Engineering, Udaipur
Er. Himanshu Pandey, Scientist

Best Oral Presentation Award by Society for Scientific Development in Agriculture and Technology
Er. Himanshu Pandey, Scientist

Women Scientist Award by Astha Foundation, Meerut
Er. H Wakudkar, Scientist

Best poster award in the International Symposium 2021
Organised by ICAR-IIAB, Ranchi and Plant Tissue Culture Association
Dr. Chirag Maheshwari, Scientist

Recognitions

Dr. Debabandya Mohapatra, Principal scientist
Fellow of the Institution of Engineers (India)

Dr. Manish Kumar, Scientist
Certificate of excellence in Reviewing by Journal of Engineering Research and Reports

Dr. Manoj Kumar Tripathi
- Top 2% Scientists in the world-2021, published by Elsevier, data compiled by Stanford University (A178095)
- Editor of the journal - Clinical Medicine Research, Science Publishing Group, USA
- Life membership of Society for Agriculture & Allied Research (SAAR), India
- Certificate of Excellence by Scientific Planet Society
- Certificate of Excellence as reviewer by Defence Life Science Journal (DRDO, Govt of India)

Dr. Manoj Kumar, Scientist (Agril. Stats)
- Certificate of excellence in reviewing from International Journal of Soil and Plant Science
- Certificate of excellence in reviewing by Plant Cell Biotechnology and Molecular Biology Journal

Dr. Manoj Kumar, FMP, Scientist
Certificate of excellence in reviewing 2021 by Current Journal of Applied Science & Technology

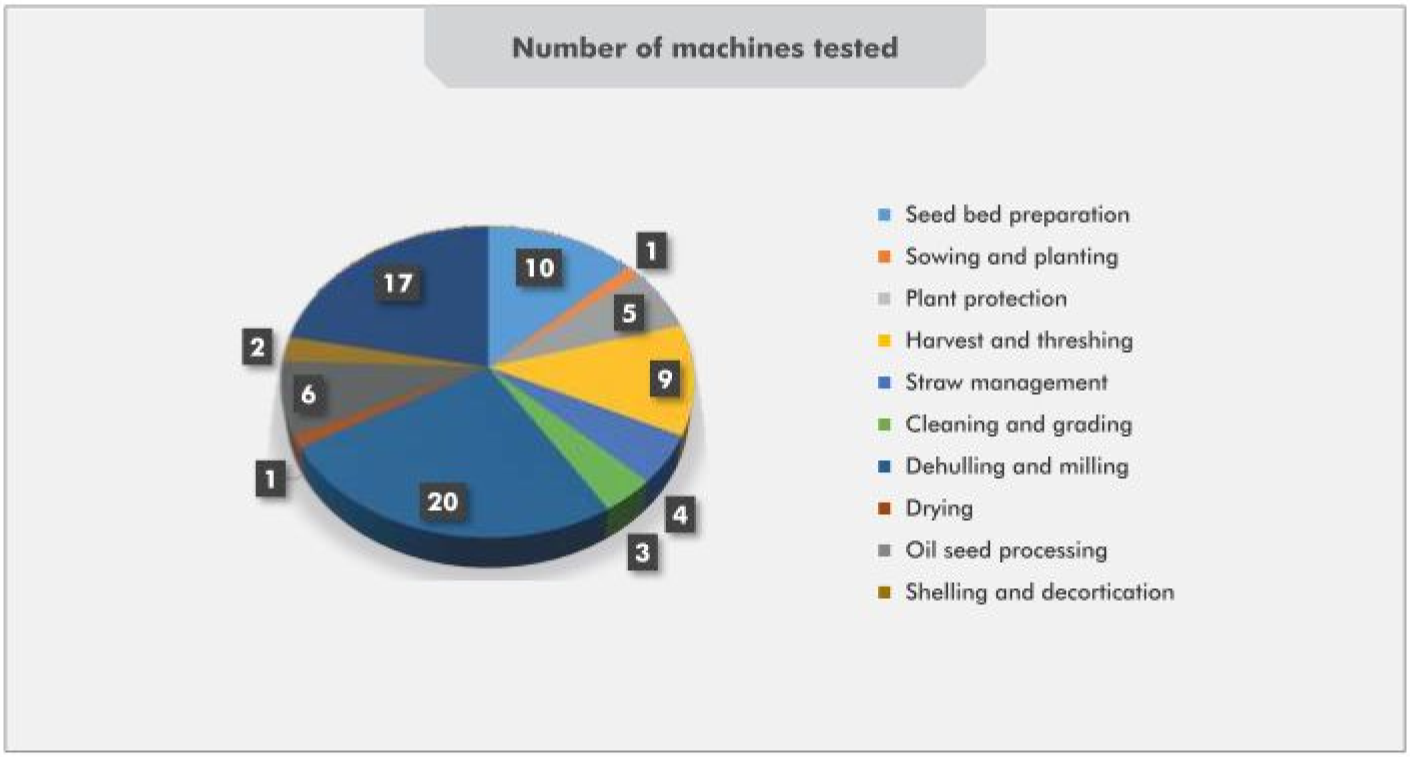
Dr. Ranjay Kumar Singh, Principal Scientist
Member of advisory board for new generation watershed projects Govt of Madhya Pradesh

LINKAGES AND COLLABORATIONS

S. No.	Organization	Collaboration
1.	ICAR-CTRI, Rajamundry, AP, India	Research
2.	ICAR-SBI, Coimbatore, India	Research
3.	ICAR-DCR, Puttur, Karnataka, India	Research
4.	ICAR-NRC Banana, Tiruchirapalli, India	Research
5.	ICAR-IISR, Lucknow, India	Research
6.	TNAU, Coimbatore, India through SERB, New delhi	Research
7.	State Line Departments, Tamil Nadu, AP, Karnataka, Kerala (India)	Extension
8.	KVKs, India	Extension
9.	NGOs, India	Extension
10.	SERB, New Delhi	TARE activity
11.	CDAC, Kolkata, and MANIT, Bhopal	NASF research funding

Commercial testing of Farm machinery & Post harvest equipment

Farm machinery and post-harvest machinery from various industries are being tested at the CIAE main campus and the regional centre in Coimbatore. During the year, CIAE tested 78 agricultural machinery under different categories generating revenue of ₹ 76.80 lakhs.



Intellectual property and consultancy

Patent granted

Application No.	Date of filing	Title	Innovators
2435/MUM/2013	17-02-2021	ICAR-CIAE Process technology for multi-nutrient composite mix for biscuits	Dr. Dipika A Murugkar

Patents filed

Application No.	Date of filing	Title	Innovator
202121006611	17-02-2021	Remote Controlled Turing Mechanism of Power Tiller with Safety Feature.	Dr. P K Pranav B S K Chhetry Anubhab Pal Mayangkaba Aier
202121012246	22-03-2021	A mechanism for cutting and windrowing of pigeon pea crop and alike	Dr. B M Nandede Dr. Dilip Jat Er. P L Pradhan Dr. C R Mehta
202121012109	22-03-2021	A mechanism to hold, cut, convey and windrows the plant stalk and collect the ear head simultaneously while harvesting of grain sorghum and alike	Dr. B M Nandede Dr. A K Roul Dr. Dushyant Singh
202121017713	16-04-2021	A precision pneumatic seed metering mechanism for hill dropping and the like	Er. M L Jadhav Dr. B M Nandede Dr. M Din Dr. P S Tiwari Dr. Dilip Jat
202121051274	09-11-2021	An orifice based hydrodynamic cavitation system for shelf stable sugarcane juice and process thereof	Dr. D Mohapatra Dr. J Bhukya Dr. R Naik
202121053533	22-11-2021	Side dispensing type farmyard manure applicator	Dr. A Khadatkar Dr. C P Sawant
202121053630	22-11-2021	Abrasive peeling machine for medicinal root crops	Dr. D Mohapatra Dr. Dilip Pawar

Copyright registered

Application Number	Date of registration	Title	Innovators
16643/2020-CO/SW Dated: 23.10.2020	No. SW-14129/2021 Dated. 20/01/21	Software for Water Balance Simulation Model for Roof Water Harvesting	Er. A M Waghaye Dr. M Kumar Dr. R D Randhe Dr. Karan Singh Mrs. Ranu Gupta

Copyrights filed

Application Number	Date of filing	Title	Innovators
20874/2021-CO/SW	31-08-2021	Software for relative chlorophyll measurement system	Dr. B B Gaikwad Dr. R R Potdar
24883/2021-CO/SW	13-10-2021	Graphic user Interface for estimating the freshness of white button mushrooms	Dr. A D Arjun Dr. S K Chakraborty Dr. N Kotwaliwale

Consultancy/ Contract Projects/ Collaborative projects / Technologies Incubated

S. No.	Name of the organization and Scientist involved	MoU for the purpose	MoU Signed on	Funding budget
1.	M/S Saint Gobain, Chennai, PI: Dr. Debabandya Mohapatra	Consultancy service for evaluation of the rice whiteners	24-09-2021	7.5 Lakhs
2.	M/s National Engineering Works Dhar, MP PI: Dr. Dilip A Pawar	Contract service for testing of flexible screw conveyor		
3.	M/s Burgeon Agri., Pvt., Ltd, Nashik, Maharashtra PI: Dr. Dilip A Pawar	Contract research project on development of modular backyard poultry cage	14-03-2019	0.35 Lakhs
4.	DBT-APSCS&T Centre of Excellence for Bioresources and Sustainable Development, Department of Science & Technology Govt. of Arunachal Pradesh, Kimin-791121, Arunachal Pradesh PI: Dr. Ravindra Naik	Consultancy for establishment of banana Fibre Extraction making and processing units across different districts in Arunachal Pradesh	13-12-2021	4.57 Lakhs

Memorandum of Understanding Signed

S. No.	Name of the organization	Purpose	MoU Signed on
1.	ICAR-CIAE, Bhopal & Madhya Pradesh Vigyan Sabha, Bhopal, M.P.	Establishment of millet processing centre at Patalkot tribal area at Harshdwari, Tamia Block, Chhindwara M.P. under Tribal Sub Plan	24-06-2021
2.	M/s National Remote Sensing Centre, NRCS, ISRO, Hyderabad	Establishment of field station for measuring ET and soil moisture under National Hydrology Project	27-07-2021
3.	The tripartite MoU with ICAR-CIAE, Bhopal as mentor institute funded by MoFPI, KSNUAHS, Shivamogga and Karnataka State Agricultural Produce Processing and Export Corporation Limited, Bengaluru	Setting up of common incubation centre at KSNUAHS, Shivamogga under ODOP Scheme.	17-09-2021
4.	The tripartite MoU for collaborative project with ICAR-CIAE-CTRI, Rajamundry and Tobacco Board, Chennai	Development and evaluation of FCV tobacco leaves stringing machine	09-11-2021

PUBLICATION

Research papers published in NAAS rated journals (>6.0 rating)

1. Bhukya J, Naik R, Mohapatra D, Sinha LK and Rao KVR. 2021. Orifice based hydrodynamic cavitation of sugarcane juice: Changes in physico-chemical parameters and microbiological load. LWT-Food Science Technology, 150, 111909 DOI:10.1016/j.lwt.2021.111909.

2. Chandel NS, Chandel AK, Roul AK, Solanke KR and Mehta CR. 2021. An integrated inter- and intra-row weeding system for row crops. Crop Protection, 145, 105642.https://doi.org/10.1016/j.cropro.2021.105642.

3. Chandel NS, Jat D, Mehta CR and Rajwade YA. 2021. Indices for comparative performance evaluation of seed drills. Agricultural Mechanization in Asia, Africa and Latin America, 52(3), 61-70.

4. Gupta A, Singh RK, Kumar M, Sawant CP and Gaikwad BB. 2022. On-farm irrigation water management in India: Challenges and research gaps. Irrigation and Drainage, 3–22, https://doi.org/10.1002/ird.2637.

5. Gupta A, Sawant CP, Rao KVR and Sarangi A. 2021. Results of century analysis of rainfall and temperature trends and its impact on agriculture production in Bundelkhand region of Central India. Mausam, 72, 2, 473-489.

6. Jyoti B, Karthirvel K, Divakar D and Senthilkumar T. 2021. Specific cutting energy characteristics of cassava stem with varying blade parameters using impact type pendulum test rig. Agricultural Mechanization in Asia, Africa and Latin America, 52 (4), 15-23.

7. Khadatkar A, Mathur SM, Dubey K and Magar AP. 2021. Automatic ejection of plug-type seedlings using embedded system for use in automatic vegetable transplanter. Journal of Scientific and Industrial Research, 80, 1042-1048.

8. Kumar A, Srivastav PP, Pravitha M, Hasan M., Mangaraj S, Prithviraj V and Verma, D. K. 2022. Comparative study on the optimization and characterization of soybean aqueous extract based composite film using response surface methodology (RSM) and artificial neural network (ANN). Food Packaging and Shelf Life, 31, 100778. https://doi.org/10.1016/j.fpsl.2021.100778

9. Kumar A, Pravitha M, Srivastav PP, Mangaraj S, Pandiselvam R and Hasan M. 2021. Development of soy-based nanocomposite film: Modeling for barrier and mechanical properties and its application as cheese slice separator. Journal of Texture Studies, 1–11. https://doi.org/10.1111/jtxs.12636.

10. Kumar M, Tamhankar MB, Mandal S, Babu VB and Jyoti B. 2021. Measuring technical efficiency and frontier intervention for farm machinery manufacturers using slacks based data envelopment analysis. Current Science, 120 (8), 1350-1357.

11. Kumar N, Sawant CP, Sharma RK, Chhokar RS, Tiwari PS, Singh D, Roul AK, Tripathi SC, Gill SC and Singh GP. 2021. Combined Effect of Disc Coulters and Operational Speeds on Soil Disturbance and Crop Residue Cutting under No-Tillage System in Soil Bin. Journal of Scientific & Industrial Research, 80, 739-749.

12. Kumar P, Chakraborty SK and Kate A. 2021. Influence of infrared (IR) heating parameters upon the hull adherence and cotyledon integrity of whole pigeon pea (*Cajanus cajan L.*) grain. LWT - Food Science and Technology, 154, 112792. https://doi.org/10.1016/j.lwt.2021.112792

13. Kumar SP, Jat D, Rao SBN, Chandrasekharaiah M, Mehta CR, Singh KP, Nandeha N. 2021. On-the-go urea spraying system of baler for enhancing the nutritional quality of paddy straw. Range Management Agroforestry, 42 (2), 328-333.

14. Kumar V, Jaiswal KK, Vlaskin MS, Nanda M, Tripathi MK, Gururani P, Kumar S and Joshi H. C. (2022). Hydrothermal liquefaction of municipal wastewater sludge and nutrient recovery from the aqueous phase. Biofuels, 13(5), 657–662. https://doi.org/10.1080/17597269.2020.1863627.

15. Kumar V, Sharma N, Jaiswal KK, Vlaskin MS, Nanda M, Tripathi MK and Kumar S. 2021. Microalgae with a truncated light-harvesting antenna to maximize photosynthetic efficiency and biomass productivity: Recent advances and current challenges. Process Biochemistry 104, 83–91.

16. Kumari L, Hasan M, Randhe RD, Singh DK, Singh AK and Alam W. 2021. Effects of coloured plastic mulches and irrigation levels on Capsicum under greenhouse. Indian Journal of Agricultural Sciences, 91 (6), 833–6.

17. Lamo C, Bargale PC, Gangil S, Chakraborty SK, Tripathi MK, Kotwaliwale N and Modhera B. 2022. High crystalline cellulose extracted from chickpea husk using alkali treatment. Biomass Conversion and Biorefinery, 1-9. 10.1007/s13399-022-02331-5.

18. Magar AP, Nandede BM, Chilur R, Gaikwad BB and Khadatkar A. 2022. Optimization of growing media and pot size for vegetable seedlings grown in cylindrical paper pots using response surface methodology. Journal of Plant Nutrition, 45(11), 1712–1721.

19. Mahanti NK, Kothakota A, Ishwarya P, Chakraborty SK, Kumar M and Cozzolino D. 2021. Emerging non-destructive techniques for fruit damage detection- A comprehensive review. Trends in Food Science and Technology, 120, 418-438 DOI:10.1016/j.tifs.2021.12.021.

20. Mandal S, Sharma RK, Bhattacharya TK, Tanna H and Haydary J. 2022. Charring of pine needles using a portable drum reactor. Chemical Papers, 76(2), 1239-1252. https://doi.org/10.1007/s11696-021-01893-4.

21. Mangaraj S, Thakur RR, Mathangi RS, Yadav A and Swain S. 2021. Shelf life enhancement of guava (*Psidium guajava cv. Baruipur*) stored under pilot scale modified atmosphere storage system. Food Science and Technology International, 27(7), 674-689. Doi: 10.1177/10820132211013269.

22. Mohapatra D, Patel AS, Kar A, Deshpande S and Tripathi M. 2021. Effect of different processing conditions on essential minerals and heavy metal composition of sorghum grain. Journal of Food Processing and Preservation, 45(1), e14909 DOI: 10.1111/jfpp.14909.

23. Nanda M, Kumar V, Arora N, Vlaskin MS and Tripathi MK. 2021. ^{1}H NMR-based metabolomics and lipidomics of microalgae. Trends Plant Science 26(9), 984–985.

24. Nickhil C, Mohapatra D, Kar A, Giri SK, Tripathi MK and Sharma Y. 2021. Gaseous ozone treatment of chickpea grains, part I: Effect on protein, amino acid, fatty acid, mineral content, and microstructure. Food Chemistry, 345, 128850.

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27. Pandiselvam R, Mahanti NK, Manikantan MR, Kothakota A, Chakraborty SK, Ramesh SV, Beegum, PPS. 2021. Rapid detection of adulteration in desiccated coconut powder: VIS-NIR spectroscopy and chemometric approach. Food Control, 133A: 108588, doi:10.1016/j.foodcont.2021.108588

28. Pawar DA, Giri SK and Sharma AK. 2021. Development and performance evaluation of grape debunching machine for production of raisins and stemless table grapes. Journal of Food Process Engineering, 44(2), e13898.

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33. Sabat M, Kotwaliwale N, Giri SK .2021. Thermography for performance evaluation of a compact, air disperser equipped hot air dryer. Food Process Engineering 44(9), e13777.

34. Shelake P, Mohapatra D, Tripathi MK and Giri SK. 2022. Explicating the effect of the ozonation on quality parameters of onion (*Allium cepa L.*) in terms of pungency, phenolics, antioxidant activity, colour, and microstructure. Ozone: Science & Engineering, DOI: 10.1080/01919512.2022.2037404.

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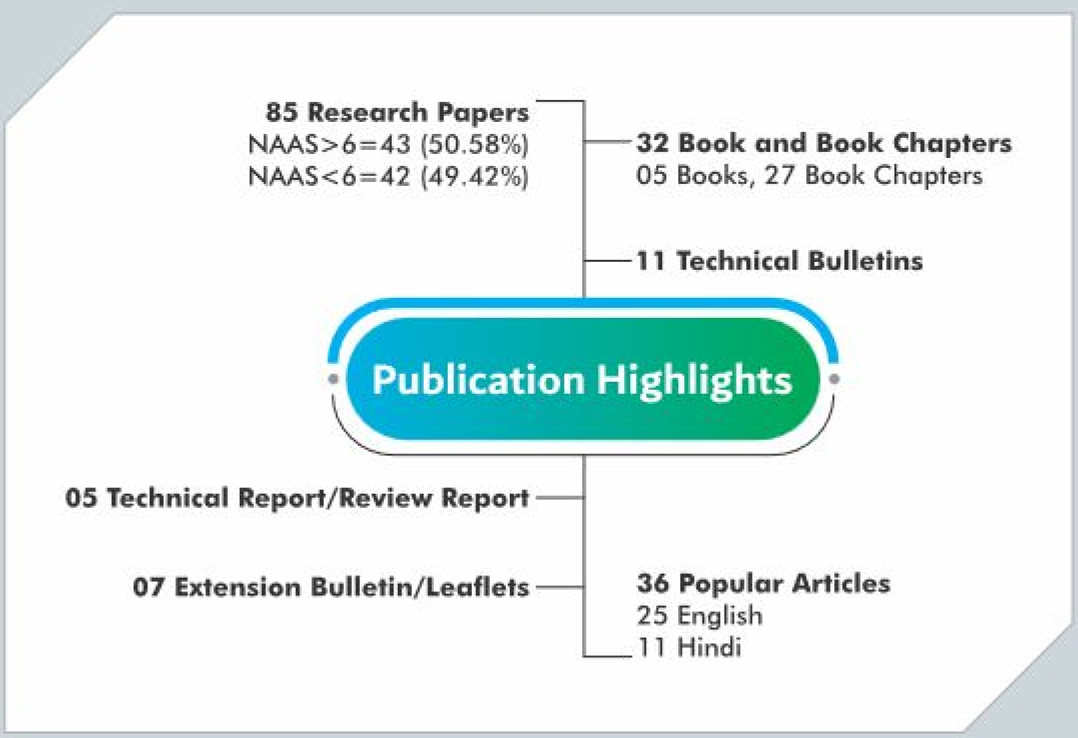

EVENTS ORGANISED DURING 2021

Annual workshop of AICRP on Increased Utilization of Animal Energy with Enhanced System Efficiency

The 20th Workshop of ICAR-All India Coordinated Research Project on Increased Utilization of Animal Energy with Enhanced System Efficiency (IUAEESE) was held on 11 January 2021 in online mode under the Chairmanship of Dr. K Alagusundaram, Deputy Director General (Agricultural Engineering), ICAR, New Delhi. Dr. Kanchan K Singh, ADG (FE), ICAR, New Delhi and Dr. C R Mehta, Director, CIAE, Bhopal, were Co-Chairmen. Dr M Din, Project Coordinator, AICRP on IUAEESE welcomed the distinguished panel of guests. The action taken report (ATR) of different review meetings, quantified progress for this year, significant quantified achievements, output, outcome and impact of last 8 years (2012-20) were presented. Seven publications, namely "**Research highlights-2020-21**", E-coffee table book on "**Animal drawn implements**" complied by Coordinating cell, One CD in English, entitled "**OUAT Ragi Thresher cum Pearler-Socio-economic booster for tribal farmers of Odisha**", one booklet in local Odia language, entitled "Pasushaktira sadupajiga nimante unnata gyan kousala" complied by OUAT, Bhubaneswar and one booklet entitled "**Pashu Chalit Unnat Krishi Yantra**" in Hindi language, one success story on "**Yashogatha**" and one folder leaflet "**Bail Chalit Saur Favarani Yantra**" in the Marathi language compiled by MAU, Parbhani Center were also released.

Annual Workshop of AICRP on Ergonomics and Safety in Agriculture

The 12th Annual Workshop of AICRP on Ergonomics and Safety in Agriculture was organized during 27-28 January, 2021 in virtual mode. The workshop was inaugurated on 27 January by Dr. K Alagusundaram, DDG (Agril. Engg), ICAR. The session was co-chaired by Dr. Kanchan K Singh, ADG (FE), ICAR and Dr. C R Mehta, Director, ICAR-CIAE. The experts Dr. L P Gite, Ex-Scientist Emeritus and Dr. P K Nag, former Director, NIOH, Ahmedabad, also graced the occasion with their presence. During the two days deliberation, research engineers of twelve centres of the scheme presented their achievements and progress of work. The discussions were held on future programmes of the scheme for period 2021-26 and centre-wise work plan for year 2021. A total of 47 people attended the workshop. A booklet on "**Safety Measures for Snakebites in Agriculture** and two e-coffee table books were released on the occasion.

Annual Workshop of the AICRP on Energy in Agriculture & Agro-based Industries

The 24th workshop of the ICAR-All India Coordinated Research Project on Energy in Agriculture and Agro-based Industries (ICAR-AICRP on EAAI) was organized on Virtual Mode during 09–11th February, 2021. The purpose of this Workshop was to review the research progress of the year 2020-21 with respect to approved technical programmes of the 16 cooperating centers and to finalize the future programmes for next year (2021-22). The meeting was chaired by Dr. K Alagusundaram, Deputy Director General (Engg.) and Co-chaired by Dr. Kanchan K. Singh, Assistant Director General (FE) of the ICAR, New Delhi and Dr. C R Mehta, Director, ICAR-CIAE, Bhopal. The subject matter experts were Prof. B S Pathak, Ex-Director, SPRERI, VV Nagar and Dr. S. Kamraj, Ex-Professor & Head, Bio-energy

Department, TNAU, Coimbatore. The workshop was attended by Dr. P L Singh, Principal Scientist, SMD (Agricultural Engineering), ICAR, New Delhi, Dr. Anil Kumar Dubey, Ex-Head, AEP Division & Ex-LCPC, CRP on EA, ICAR-CIAE Bhopal, PC (FIM), PC (ESA) & PC (UAE) along with the 16 cooperating centre with their scientific staff and RA/SRF participated in the XXIV workshop. Dr. K C Pandey, PC (EAAI) welcomed the chairman, co-chairman, experts and all delegates. Publications, namely **Research highlights cum coordinator's report 2020-21**, complied by PC Cell, "**Drying characteristics of agricultural produces-2021**", complied by GBPUA&T, Pantnagar centre, "**Sampling methodology for energy audit survey-2021**", compiled by ICAR-IASRI, New Delhi and AICRP on EAAI, ICAR-CIAE, Bhopal, one E-coffee table book on "Gadgets/technologies developed under ICAR-All India Coordinated Research Project on Energy in Agriculture and Agro-based Industries, 2021" compiled by TNAU, Coimbatore centre were released on this occasion.

Brainstorming session on Automation in Agricultural Engineering

CIAE RC-Coimbatore organized a brainstorming session on 'Automation in Agricultural Engineering' through virtual mode on 19 February, 2021. The purpose of the session was to discuss the status and need of automation in agricultural engineering and way forward to enhance input use efficiency and reduce drudgery of agricultural workers. The programme was chaired by Dr. C.R. Mehta, Director, ICAR-CIAE, Bhopal. In his inaugural address, he highlighted the importance and the need of automation in agricultural engineering in the global/ Indian context and the way forward. About 85 invited experts/ Scientists/ faculty members from various ICAR Institutes, SAUs, and PIs of various AICRPs/ AICTE approved Institutions and Deemed Universities attended the session. Five invited talks, "**Automation in Farm mechanization**" by Dr. H.L Kushwaha, Principal scientist, IARI, New Delhi; "**Application of robotics in farm mechanization**" Dr. Dhanashri Balaso Shinde,

R&D Engineer, Automation of cultivation system, Farmship, Inc, Tokyo, Japan, "**IOT based start-ups in Agriculture and Allied field**" by Dr Gawthaman Ramasamy, Vice President, Kultivate.in, Coimbatore; **IoT enabled food grain warehouse monitoring**" by Dr Balaji Ganesh, Dean (Research), Velammal Engineering College, Chennai, "**Automation in Micro Irrigation System**" by Er.Tushar Karande, Manager for Digital Farming Solutions, NETAFIM, Maharastra, were delivered. The lectures were followed by discussion to identify areas of immediate attention and way forward for automation in agriculture for small landholding.

Annual Workshop of AICRP on Farm Implements and Machinery

The 35th Annual Workshop of AICRP on Farm Implements and Machinery was organized on virtual platform during 23-25 February, 2021. Around 100 participants from different SAUs, ICAR institutes and other organizations attended the workshop. Inaugural session of the workshop was held on 23 February, 2021 under the Chairmanship of Dr. K. Alagusundaram, DDG (AE), ICAR, New Delhi and Dr. C. Divaker Durairaj, Former Dean, AEC&RI, TNAU, Coimbatore was the Guest of Honour during the session. Dr. C.R. Mehta, Project Coordinator, AICRP on FIM presented Project Coordinator's Report on progress of work done by different centres of the scheme. Technical Sessions – I and II were conducted during 23-25 February, 2021 to take the stock of the progress made by 25 centres engaged in Research & Development (R&D), Prototype Manufacturing Workshop (PMW), Prototype Feasibility Testing (PFT) and Front Line Demonstration (FLD) activities. Two booklets: "**Success Story on Impact of PFT & FLD Activities**" by Allahabad Center, and "**Research Digest: 1960-2021**" by Coimbatore Center, a folder on "**Mat Type Nursery Raising for Transplanting**" by Barapani center, a Booklet on "**Chara Phasalon ke Utpaadan Evam Sanrakshan Hetu Krishi Yantra**" by Jhanshi center, and two Coffee-Table e-Books on **Technologies Developed** by

Coimbatore center and **Recent Technologies** by PC Cell, were released on the occasion.

RAC Meeting

The 26th meeting of the Research Advisory Committee (RAC) of the Institute was held during 9-10 March, 2021. Dr. C.R. Mehta, Director welcomed the Chairman and members of the Research Advisory Committee. In his welcome address, Dr. Mehta highlighted the major achievements of the institute during 2020-21. Dr. N. C. Patel, Chairman RAC, in his opening remarks emphasized to develop the linkage with the industries across the countries for disseminating the technologies developed by the CIAE. Dr. Kanchan K. Singh, ADG (FE), ICAR stated that the research in AI, robotics and IoT should be initiated and be done in fast-track mode. He further suggested to develop a self-sustaining business model for the industries. The other expert members of RAC who provided valuable advice to CIAE Scientists included Dr. Jaskaran Singh Mahal, Director of

Extension Education, PAU; Dr. K.N. Tiwari, Professor (HAG), Agricultural & Food Engineering Department, IIT, Kharagpur; Dr. Balaram Panigrahi, Professor & Head, SWCE, CAET, OUAT, Bhubaneswar; Dr. Balasankari, Executive Director, Renewable Cogen Asia, Chennai and Dr. G.P. Sharma, Professor, CTAE, Udaipur. The RAC members also witnessed virtual demonstration of some new technologies developed by the institute.

World Water Day Celebration

World Water Day was celebrated on 22 March, 2021. An expert talk-cum-discussion meeting was organized online. Dr. S.K. Ambast, Joint Director (Edn.), ICAR-NIBSM, Raipur and Former Director, ICAR-Indian Institute of Water Management, Bhubaneswar, was the Chief Guest for the occasion. Dr. C.R. Mehta, Director, ICAR-CIAE, Bhopal chaired the meeting. Dr. Ambast delivered an expert lecture on "**Importance of Water in different spheres of life**". He presented many aspects and scenarios of water availability and its utilization using several management options and emphasized that water management should be a way of life. Scientists and staff of the institute attended the celebration.

CIAE-Regional Centre, Coimbatore, celebrated World Water Day on the theme '**Valuing Water**' at Yelur village (MGMG village), Madhukarai block, Coimbatore district in collaboration with ICAR-Indian Institute of Soil and Water Conservation Regional Centre (Ooty, TN) and leading manufacturers of drip/rain hose and farm

machinery. About 85 farmers (men & women) attended this programme. Dr. S Balasubramanian, Principal Scientist & Head, CIAE-RC, detailed about the theme of world water day during his talk and he emphasized the farmers to adopt recent technologies to conserve moisture and save water. The farmers were also provided with AV aids and relevant literature in bilingual form.

Brain Storming Session on *Strategies for Aatma Nirbhar Bharat in Agricultural Mechanization*

The institute organized a brain storming session through virtual mode on "**Strategies for Atma Nirbhar Bharat in Agricultural Mechanization**". The theme was chosen under the Atma Nirbhar Bharat mission, recently launched by Government of India. The aim of the brain storming session was to identify specific areas of agricultural mechanization in coming years to ensure a self-reliant India. The session was chaired by Dr. K. Alagusundaram, Deputy Director General (Engg.), ICAR, New Delhi and Ms. Shomita Biswas, Joint Secretary, DoAC & FW, Govt. of India, New Delhi was the Chief Guest. The session was co-chaired by Dr. Kanchan K. Singh, ADG (FE), ICAR and Shri T.R. Kesavan, President & Chief Operating Officer, TAFE & President, Tractor and Mechanization [TMA] and Chairman, FICCI, National Agriculture Committee. About 100 delegates including national and state level policy makers, academia and R&D institutes, and allied industries, and agricultural machinery manufacturers participated in the brain storming session and deliberated on the theme. The lead papers on the theme were presented by Shri V.N. Kale, Additional Commissioner (M&T), DOAC & FW, Govt. of India and Shri T.R. Kesavan. Dr. C.R. Mehta, Director, ICAR-CIAE, Bhopal delivered welcome address and presented the current status of agricultural mechanization in India and highlighted the need and importance for preparing the strategies for *Aatma Nirbhar Bharat* in the sector of agricultural mechanization in the country. Dr. Kanchan K. Singh stated that the farm machinery sector in India has grown a lot during the last decades and called upon R&D

Institutes to develop small and smart multipurpose farm machinery and tools suitable for different agro-climatic zones. Chief Guest, Ms. Shomita Biswas congratulated ICAR-CIAE, Bhopal for organizing the brain storming session on this important theme and stressed upon the need for Institute-Industry-Policy Makers to work in tandem to develop a policy framework for *Aatma Nirbhar Bharat* in agricultural mechanization sector. She also stressed upon the need to strengthen the ICAR and DOAC & FW interface for effective results. The Chairman of the session, Dr. K Alagusundaram, stated that the agricultural mechanization should now focus on creation of facilities for storage, primary, secondary and tertiary processing and value addition of perishable, semi perishable and highly perishable agro produce in the production catchment. Further, there is need to create agro processing and agri-business incubation centres to support advanced processing technologies and create custom hiring centres for post-harvest processing and value addition so as to facilitate Aatma Nirbhar Bharat mission launched by Govt. of India.

ICAR Regional Committee meeting No. VII

The 26th meeting of ICAR Regional Committee No. VII was organized by ICAR-CIAE, Bhopal on 25 August, 2021 through Video Conferencing to identify issues related to agriculture, horticulture, animal husbandry and fisheries sectors in the states of Madhya Pradesh, Maharashtra, Chhattisgarh and Goa and to provide solutions for those issues. Hon'ble Union Minister of Fisheries, Animal Husbandry and Dairying Shri Parshottam Rupala inaugurated the meeting in the presence of Hon'ble Union Ministers of State for Agriculture and Farmers Welfare Shri Kailash Choudhary and Ms. Shobha Karandlaje, and Minister for Farmer Welfare and Agriculture Development, Govt. of Madhya Pradesh, Shri Kamal Patel, Departmental Secretaries and other senior officers of Agriculture, Horticulture, Animal Husbandry & Fisheries Departments from the States of Chhattisgarh, Goa, Madhya Pradesh and Maharashtra were present. The meeting was also attended by the Vice-chancellors of State Agricultural Universities, Governing Body Members of ICAR, and dignitaries from ICAR (DDGs, ADGs and others), Directors of ICAR Institutes and ATARIs of the region.

Dr. Trilochan Mohapatra, Secretary, DARE, GoI & DG, ICAR, New Delhi in his address, briefed about the genesis of the regional committees. He lauded the states of the region for their achievements in agriculture and allied sector in last two years and highlighted some key analysis regarding cropping intensities, farm income, seed replacement rates, livestock populations and yield gaps with reference to four states. Shri Kailash Choudhary talked about the present challenges encountered by the agricultural sector like reducing availability of water, nutrient deficiency in soils, climate change, etc. Shri Parshottam Rupala informed that agriculture research and technology development enabled the country to increase the production of food grains, horticultural crops, fish, milk, eggs, etc. by many folds during the last 70 years, thus making a visible impact on the national food and nutritional security. Dr. C R Mehta, Director, ICAR-CIAE, Bhopal and Member Secretary of the ICAR Regional Committee-VII proposed the vote of thanks during the inaugural session. Dr. S P Kimothi, ADG (Technical Coordination), ICAR proposed the vote of thanks at the end of the technical session.

Webinar on 'Resilience and Cope-up Strategies in Pandemic through Agricultural Engineering Interventions: Women's Perspective'

ICAR-CIAE organized a national webinar on '**Resilience and Cope-up Strategies in Pandemic through Agricultural Engineering Interventions: Women's Perspective**' on 9 June 2021 with an objective of augmenting the women-friendly agricultural engineering technology adoption and mitigating the farm crises during Covid-19 pandemic towards enhancing their livelihoods. The webinar was chaired by Dr. K Alagusundaram, DDG (Agril Engg), ICAR and co-chaired by Dr. K K Singh, ADG (FE), ICAR; Dr. C R Mehta, Director, CIAE and Dr. D Dutta, Advisor and Head, SEED

Department, DST, New Delhi. The webinar was attended by 140 participants from ICAR institutes, SAUs and SEED Division (DST) having a background in Agricultural Engineering. Eight lectures were delivered by the experts on the topics e.g. women centric schemes - funding opportunities by DST, women friendly ergonomic tools and implements for inclusive development, drudgery reduction and women empowerment in agriculture during post Covid-19, ICAR-CIAE technologies for entrepreneurship through processing and value addition, ICAR-CIPHET technologies for entrepreneurship through processing and value addition, gender sensitive agri technologies to combat post Covid-19, women empowerment through women technology park success story of KVK and tribal women custom hiring business model. The presentations were followed by discussion on the theme. Dr. K Alagusundaram stressed the need of unlocking India's potential in agriculture sector for women empowerment. He predicted a boom in women entrepreneurs in the coming years and concluded his address by requesting delegates to closely follow government's initiatives to tap into new areas to resonate the identity of rural women. Dr. Debapriya Dutta, Advisor and Head, SEED Division, DST emphasized the need of women entrepreneurship and their business leadership for rural prosperity. Dr. K K Singh, ADG (FE), ICAR shared his thoughts on key improvements in women friendly tools and implements

through the contribution of ICAR, SAUs, and AICRPs, and appreciated the remarkable growth seen in start-ups by women. In his closing remarks, Dr. C R Mehta, Director, CIAE hoped that the sessions were productive and helpful for the attendees. Dr Mehta urged the delegates to concentrate on the emerging areas on development of women centric technologies in three ways - reactively, proactively and actively. He hoped that this webinar would pave the way to create a dynamic women-friendly environment in agriculture through engineering interventions. The session concluded with a vote of thanks proposed by Dr R Senthil Kumar, Senior Scientist and Convenor of the webinar.

Webinar for ITI trade holders

A Webinar on "**ICAR-CIAE Regional Centre: A Boon for ITI-TATP**" was organized for ITI trade holder at CIAE-RC, Coimbatore on 24 August, 2021. The

program was inaugurated by Dr. C R Mehta, Director, ICAR-CIAE, Bhopal. Dr. S Balasubramanian, Principal Scientist & Head, ICAR-CIAE Regional Centre welcomed the participants and enumerated the importance of the webinar. The aim of the webinar was to showcase the opportunities for the ITI trade apprenticeship training programme at CIAE Regional Centre. The programme was attended by various stakeholders, viz., Mr. T V Rajasekar, Deputy Director, Regional Directorate of Skill Development and Entrepreneurship (RDSD&E), Chennai, Mr. Selvarajan, Deputy Director, Regional Joint Director and Training (RJD&T), Coimbatore, Dr. K N Agarwal, Project Coordinator, AICRP on Ergonomics and Safety in Agriculture, ICAR-CIAE and Mr. A Rajkumar, Vice President, Agricultural Machinery Manufacturer Association. About 300 participants including ITI Principals, Placement Officers, Training Officers, students in Govt. ITI's, Scientists, Technical Officers, Technicians and officials from ICAR-CIAE participated in this programme. The selected candidates of ITI-TATP for the year 2021 were also introduced.

Events organized to celebrate *Azadi ka Amrit Mahotsav*

National Conference

As a part of the Azadi Ka Amrit Mahotsav (75th anniversary of India's Independence), ICAR-CIAE, Bhopal organized a National conference on "कोविड-जनित 19 परिस्थितियों में देश के आर्थिक विकास एवं आत्मनिर्भरता में कृषि अभियांत्रिकी की भूमिका" in online mode during 28-29 July, 2021. Dr. Suresh Kumar Chaudhari, Deputy Director General (NRM & Agricultural Engineering), ICAR, New Delhi chaired the opening ceremony. Dr. K K Singh, ADG (Farm Engineering) and Dr. S N Jha, ADG (Process Engineering) co-chaired the function. Dr. S K Chaudhari in his address highlighted the contribution of ICAR in the most difficult times caused due to Covid-19 pandemic. He reiterated that modernization of agriculture through engineering interventions provided self-sufficiency in food and helped India in maintaining economic growth under covid-19 situation. Dr. C R Mehta, Director, ICAR-

CIAE, Bhopal highlighted the objectives of the conference and described it as an important forum to discuss and explore the practical challenges that would emerge post Covid-19 scenarios in the field of agriculture engineering. He added that the role of engineering and technological interventions would play a very important role in achieving the concept of "Aatma Nirbhar Bharat" in agriculture. Dr. K K Singh highlighted the importance of agricultural engineering intervention for increasing resource use efficiency. Dr. S N Jha told that the conference would certainly provide a big ground to academia, scientists, researchers and research scholars by sharing their experiences. This would result on various aspects of agricultural engineering technologies for building up the sustainable solutions. The conference had five technical sessions in the different theme areas. Dr. R K Singh, ADG (Commercial Crops), presided over the valedictory function and Dr. Nawab Ali, Former DDG (Engg), ICAR, was the Chief Guest for the occasion. Total 58 oral papers and 12 posters were presented in the conference, while more than 150 officials having academic and scientific backgrounds from different regions of the country participated in the conference.

Webinars

In commemoration of 75 years of India's independence, ICAR-Central Institute of Agricultural Engineering (ICAR-CIAE), Bhopal organised a series of webinars to celebrate "***Azadi Ka Amrit Mahotsav***" on "**Challenges and Opportunities in Agricultural Engineering**". Listed below are the webinars organised:

Recent Advances in Farm Mechanization and Value Addition in Agriculture

ICAR- CIAE, Bhopal in collaboration with ICAR-ATARI, Zone-IX, Jabalpur organized an online interface meeting on "**Recent Advances in Farm Mechanization and Value Addition in Agriculture**" on 18 August, 2021. A total of 130 participants participated in this programme from KVKs including officials from Madhya Pradesh and Chhattisgarh State, NGOs and FPOs. The inaugural programme was held under the chairmanship of Dr. C R Mehta, Director, ICAR-CIAE. Distinguished dignitaries included Dr, S R K Singh, Director ATARI, Jabalpur, Dr. R P Tiwari, DES, CGKV, Durg, Dr. D P Sharma, DES, JNKVV, Jabalpur and Dr. S C Mukherjee, DES, IGKV, Raipur. It was emphasized that cost-effective farm machinery, developed by ICAR-CIAE need to be popularized among the farming community through custom hiring basis in Madhya Pradesh and Chhattisgarh states to reduce the cost of cultivation and increase the farm income. Technical sessions were divided into two parts. Technical Session I covered the deliberations on recent farm machinery/technologies, efficient agricultural water management practices, CIAE Technologies for post-production in agriculture and energy generation and value addition from crop residue. Technical Session II covered the lectures on the role of soybean processing in doubling farmers' income, women friendly farm technologies and use of animal power in agriculture. Dr. S R K Singh emphasized that interface programme should be organized quarterly to minimize the technological gap. He also urged that KVKs should adopt the technologies and promote the CIAE developed technologies among the farmers for their benefits according to their need. Director, ICAR- CIAE urged the participants specially KVKs, State and District level officials to adopt and disseminate the CIAE technologies for the benefit of the farmers and also advised KVK Scientists to promote the technologies through custom hiring mode, besides encouraging farmers for entrepreneurship development and to promote the straw combine harvester, straw mulcher and straw bailer implements for proper crop residue management.

Eat Smart Right from Start

To mark the National Nutrition Week (1-7 September) and ***Azaadi ka Amrut Mahotsav***, ICAR-CIAE in association with Nutrition Society of India- Bhopal Chapter organized a National Webinar on 7 September, 2021. The webinar began with a brief introduction and welcome by Dr Dipika Agrahar Murugkar, Principal Scientist, ICAR- CIAE, Bhopal followed by Dr Preeti Chandurkar, Convenor, NSI-Bhopal Chapter who explained the role and working of the chapter in Bhopal.

This was followed by talks by eminent speakers, Dr Meenakshi Bakshi Mehan, Head, Food and Nutrition Department, MS University Baroda and Dr Nachiket Kotwaliwale, Director, ICAR- CIPHET, Ludhiana. Dr Mehan in her talk emphasized key issues related to nutrition in India and gave insightful solutions to the India's biggest problem of mal-nutrition. She said that if the nutrition fraternity works together then it would be a great step towards eradication of malnutrition. Dr. Kotwaliwale spoke on the role of food processing in improving nutrition. He showcased many technologies and useful equipment for food processing developed by ICAR-CIAE and ICAR-CIPHET. More than 500 participants joined this webinar from all over India.

Roadmap on Agricultural Mechanization in state of Madhya Pradesh

A national webinar on "**Roadmap on Agricultural Mechanization in State of Madhya Pradesh**" was jointly organized by Indian Society of Agricultural Engineers (ISAE) Bhopal chapter, ICAR-CIAE and Directorate of Agricultural Engineering, Madhya Pradesh on 21 September, 2021 to celebrate ***Azadi ka Amrit Mahotsav***. The program was graced by 182 participants from research institutes of ICAR, tractor and farm machinery manufacturers, MP state department officials, students and entrepreneurs. Dr. Shrikant Patil, Chairman, CRISP and advisor to the Chief Minister, Govt. of Madhya Pradesh graced the occasion as Chief Guest of the function. The event was chaired by Dr. Kanchan K Singh, ADG (FE), ICAR, New Delhi and

co-chaired by Dr. Indra Mani Mishra, President ISAE. Dr. Shrikant Patil in his inaugural address emphasized the need of skill development in agriculture especially in the field of mechanization. Dr. Kanchan K Singh, Chairman of the session stressed the need to prepare a road map to enhance farm productivity and to reduce regional disparity in farm power availability and crop burning activities in the state. Dr. C R Mehta, Director and Patron, ISAE Bhopal chapter, appreciated the contribution of MP in farm mechanization and emphasized the scope of accelerating farm mechanization in MP due to better average land holding size, availability of workforce in agriculture, presence of R&D institutes and Directorate of Agricultural Engineering in the state.

Five presentations on different aspects of agricultural mechanization in MP were made in two technical sessions. During the interaction session, many aspects and issues related to agricultural mechanization and quality issues in the farm machinery manufacturing along with ground level issues were discussed. The programme ended with a vote of thanks proposed by Dr K N Agrawal, Vice President, ISAE, Bhopal Chapter and PC, ESA.

Early diagnosis of crop issues using drone based hyper-spectral imaging

A Webinar on "**Early diagnosis of crop issues using drone based hyper-spectral imaging**" was organized on 25 October, 2021. Around 86 participants mainly the Scientists from ICAR-CIAE, Bhopal, ICAR-CIPHET, Ludhiana and from different centres of AICRPs attended the webinar. Er. Rishabh Chaudhary, Partner, Start-up M/s Bharat Rohan was the speaker on this occasion. Er. Chaudhary in his presentation informed that he along with his colleague Mr. Amandeep Panwar started their start- up in the year 2016 after undergoing a training programme at ICAR-NAARM, Hyderabad. His team works in the Barabanki district of Uttar Pradesh and they offer early diagnosis solution to farmers using drone and hyperspectral imaging technologies. They

also provide forward and backward linkages to farmers in crop cultivation and its marketing to multi-national companies. The activity has played a vital role in increasing farmers' income, reducing their crop losses and fetching better price. At present, his start-up is working with farmers growing paddy, potatoes and mentha crop in about 4000 ha land. Various national and international agencies are collaborating with them, especially ICAR institutes and CSIR-CIMAP, DBT, BIRAC, ICICI and HDFC Bank, dlabs, BatSpec, Samunati.

Post-Harvest Quality Control and Value Chain

A Webinar on "**Post-Harvest Quality Control and Value Chain in Horticulture**" was organized on 1 November, 2021 in the series of events under celebration of 75th year of **Azadi ka Amrut Mahotsav**. Around 66 participants from ICAR institutes mainly ICAR-CIAE, Bhopal and ICAR-CIPHET, Ludhiana, Scientists from different centres of AICRPs and eminent Scientists from different parts of the country attended the webinar. Er. Kshitij Thakur, Partner, Start-up M/s

Agro grade was the speaker on this occasion. Er. Kshitij in his presentation informed that he along with his colleague Mr. Rakesh started start- up in the year 2016 after completing his B. Tech in Mechanical Engineering. His team works in the Nasik district of Maharashtra. They offer solution about grading of farm produce to farmers and traders using AI based sorting technique. They also provide forward and backward linkages to farmers for marketing of different grade of produce. Their venture have developed an AI based farm produce sorting and grading machine which can be customized according to need of the customer. At present their start-up is working on potato and tomato grading. The start-up has also linkages and collaboration with various agencies like IGKV, Raipur, INAIN (an initiative of Bill Gate Foundation), Govt. of Maharashtra, Tata Trust, Villgro, etc. The participant Scientists had very good interaction with respect to challenges faced by start- up in its initial phase and implementation of high tech solution at ground level.

Agriculture and Environment: the Citizen Face

A National Campaign on the theme "**Agriculture and Environment: the Citizen Face**" was organised on 26 November, 2021 in the series of events under celebration of 75th year of ***Azadi ka Amrut Mahotsav***. About 70 school children and 10 school teachers of Deepshikha Children higher School, Nayapura, Bhopal

participated in the event. The institute organized orientation program for school children about opportunities in agriculture sector for entrepreneurship and employment, visits to different demonstration plots at Institute campus and drawing competition on related theme.

हिन्दी पखवाड़ा 2021

केन्द्रीय कृषि अभियांत्रिकी संस्थान, भोपाल में हिन्दी पखवाड़ा 2021 कार्यक्रम 14 से 28 सितम्बर 2021 तक आयोजित किया गया। दिनांक 14 सितम्बर 2021 को संस्थान के कार्यवाहक निदेशक डॉ के एन अग्रवाल द्वारा पखवाड़े का औपचारिक उद्घाटन किया गया। हिन्दी पखवाड़ा कार्यक्रम का समापन समारोह 04 अक्टूबर को सम्पन्न हुआ। हिन्दी पखवाड़े के दौरान आयोजित विभिन्न प्रतियोगिताओं जैसे– सामान्य हिन्दी प्रतियोगिता, हिन्दी कार्यक्रम (तकनीकी कर्मचारियों अधिकारियों के लिए महिलाओं के लिए हिन्दी प्रतियोगिता, निबंध लेखन प्रतियोगिता (सभी ऑफलाइन वाद विवाद प्रतियोगिता वैज्ञानिक शोध पत्र व पोस्टर प्रदर्शन तथा गैर हिन्दी भाषी कर्मचारियों / अधिकारियों के लिए (ऑनलाइन प्रतियोगिता आयोजित

की गई एवं विजेताओ को पुरस्कार एवं प्रमाण पत्र प्रदान किये गये। इस अवसर पर संस्थान के निदेशक डॉ सी आर मेहता ने हिन्दी को आगे बढ़ाने हेतु किये जा रहे प्रयासों पर प्रकाश डाला और भविष्य में लक्ष्य पूर्वक हिन्दी के विकास हेतु प्रयास करने का आह्वाहन किया। हिन्दी पखवाड़ा संयोजन समिति के अध्यक्ष डॉ पी एस तिवारी ने हिन्दी के प्रचार प्रसार हेतु किये जा रहे प्रयासों पर चर्चा की तथा हिन्दी पखवाड़ा के दौरान आयोजित प्रतियोगिताओं का विवरण दिया। संस्थान के निदेशक महोदय ने इस अवसर पर सभी से हिन्दी में अधिकाधिक कार्य करने का आह्वाहन किया तथा कहा कि सभी वैज्ञानिक गण हिन्दी में बुलेटिन प्रकाशित करें और दूरदर्शन समाचार पत्र व अन्य ई– माध्यमों से कृषि यंत्रों की जानकारी किसान भाइयों तक पहुचायें जिससे किसान लाभान्वित हों तथा कृषि का उत्तरोत्तर विकास हो सके। इस अवसर पर मुख्य प्रशासनिक अधिकारी श्री कुमार राजेश ने भी अपने विचार व्यक्त किए। कार्यक्रम का संयोजन डॉ पी एस तिवारी एव संचालन डॉ एस पी सिंह ने किया। धन्यवाद प्रस्ताव राजभाषा प्रकोष्ठ के श्री राजेश तिवारी द्वारा किया गया। पखवाड़े के उद्घाटन व समापन सहित अधिकांश कायर्क्रम ऑनलाइन आयोजित किए गए।

World Food Day

A programme was organized on 16 October, 2021 to commemorate the occasion of "**World Food Day**" and National Campaigns under ***Azadi Ka Amrit Mahotsav*** through online mode by ICAR-CIAE Bhopal and Association of Food Science and Technology, India (AFSTI), Bhopal Chapter. The theme of the program was "***Our actions are our future: Better production, better nutrition, a better environment and a better life***". About 105 participants, mainly the food processors, entrepreneurs, research/academic professionals and the rural youth attended the programme. Dr. RT Patil, Former Director, CIPHET, Ludhiana delivered the keynote talk on "**Post-harvest operations for sustainable future**". He highlighted on the opportunities of processing of different agro-commodities for value addition, prevention of post-harvest losses and sustainable development. He also focussed on the importance of minimal processing and secondary agriculture with changing market demand.

Two talks were delivered by successful entrepreneurs i.e. Ms. Ruchira Musale, Nirmal Soy Food Products, Nagpur, Maharashtra and Ms. Neha Kumari, Founder-Hello Smile NGO, Patna, Bihar. Both the entrepreneurs underwent training on soy processing at ICAR-CIAE, Bhopal and have established their own business. Dr. Nawab Ali, Former, DDG (Engg.), ICAR, New Delhi gave his valuable remarks on global food hunger, human health and strategies of food processing in India. There was a brief interaction between participants and the speakers on the business queries and future course of actions.

Swachhta Mission

Swachhta Campaign was organized by ICAR- CIAE, Bhopal from 02- 31 October 2021. Under Swachhta campaign various activities were organized as per ICAR guidelines. On 12.10.2021 a special programme on "**Waste to Wealth**" was organized under swachhta campaign in both online as well as offline mode. Swami Nityagyananand Ji Maharaj, Secretary-Ramakrishna

Mission, Bhopal was the chief guest of the program that was presided by Dr.CR Mehta, Director of the Institute. Dr. Punit Chandra, Principal Scientist was the chairman of the Swachhta campaign programme.

Swachhta Pakhwada

Swachhta Pakhwada was organized at main campus and regional station of the institute during 16-31 December, 2021. The programme was inaugurated by Dr. CR Mehta, Director ICAR-CIAE, Bhopal on 16 December by taking oath of cleanliness by the staff of the institute. Some of the programmes organized during the pakhwada were:

- Proper garbage disposal, water conservation and its recycling at a residential colony near CIAE campus
- Kisan Diwas
- Cleanliness campaign at market place near the institute
- Poster competition for school children of Jagriti Vidya Mandir, Higher Secondary School, Karond, Bhopal to create cleanliness awareness amongst them

On 30 December, 2021, Dr. Pradeep Dey, Project Coordinator, Soil Test Crop Response, ICAR-Indian Institute of Soil Science, Bhopal addressed the staff of the institute and informed the house on waste management, utilization of organic waste and converting it into wealth. The event was concluded on 31 December, 2021 under the chairmanship of Dr. C R Mehta, Director CIAE in which media personnel were also invited to the institute. All the activities carried out by the institute during the pakhwada were briefed by Dr. RK Singh, Chairman of the event. Swachhta Pakhwada was organized by ICAR- CIAE, Bhopal from 16 -31 December 2021, as per ICAR guidelines. Kisan Diwas was celebrated on 23.12.2021 as per instructions given by ICAR.

Krishi Yantra Nirmata Diwas

"**Krishi Yantra Nirmata Diwas**" event was organised on 18 November 2021, in which 40 agricultural machinery manufacturers of Madhya Pradesh and officials from ICAR-CIAE Bhopal, and Directorate of

Agricultural Engineering, Bhopal, participated. Shri Om Prakash Chouksey, President, MP State Krishi Yantra Nirmata Sangh highlighted the issues and the difficulties faced by manufacturers of the state and submitted memorandum for support from the Government. Director, ICAR-CIAE, Dr. C R Mehta and Joint Director, Directorate of Agricultural Engineering, Govt. of MP, Er. PS Shyam, gave their suggestions and guidance and assured for solution and support to manufacturers on various issues raised during the event.

IRC Meeting

The 105th Institute Research Council meeting was held in online mode in three sessions during January 2021, participated by 64 members of IRC. Thirty projects (13 RPF-I, 6 Extension Proposal and 11 RPF-III) were discussed and reviewed during the IRC. Dr. C R Mehta, Chairman, IRC and Director, ICAR-CIAE welcomed all the members and congratulated the Scientists for their

sustained efforts in spite of difficulties faced due to COVID-19 pandemic. He instructed all the members to maintain punctuality and submit action taken report (ATR) on time. He also emphasized that good publications are to be made from every project and efforts should be made by the investigators for further dissemination of their technologies to the users, wherever applicable. He also re-iterated that Scientists should formulate research projects based on national need, government policies & initiatives, and recommendations of major committees. Dr. S Mandal, Member-Secretary, IRC presented the follow-up action on adopted RPF IIIs and action taken report of 103rd and 104th IRC meetings. He thanked all the members for providing the information required for compilation of agenda items and fruitful deliberations in the meeting.

Republic Day celebration

The 71st Republic Day was celebrated in the institute premises with enthusiasm and gaiety following the COVID-19 protocols. Dr. C R Mehta, Director, ICAR-CIAE hoisted the National Flag and addressed Scientists, officers and other employees. In his address,

Dr. Mehta highlighted about the national agricultural scenario and significant role of the institute in agricultural engineering development in the country. He called upon everyone to understand their role and responsibility in the development and prosperity of the country.

Foundation Day celebration

Institute celebrated its 46th Foundation Day on 15 February, 2021 through live as well as virtual mode. Dr. K Alagusundaram, DDG (Engg.) ICAR, New Delhi was the Chairman on the occas ion and Dr. Kanchan K Singh, ADG (FE), ICAR was co-chairman. Dr. S.N. Jha, ADG (PE), ICAR and Dr. V P Singh, Director, ICAR-NIHSAD, Bhopal and Directors of ICAR-institutes under SMD (Engg), Dr. P G Patil, Director, ICAR-CIRCOT, Mumbai, Dr. K K Sharma, Director, ICAR-IINRG, Ranchi, Dr. D B Shakyawar, Director, ICAR-NINFET, Kolkata, Dr.

Nachiket Kotwaliwale, Director, ICAR-CIPHET, Ludhiana were also present. Dr. C R Mehta, Director, ICAR-CIAE in his welcome address greeted the guests and dignitaries and highlighted the significant achievements of ICAR-CIAE during the year. He presented R & D achievements of the institute, technologies developed and commercialized, IPRs filed and awards and recognitions earned by the institute and its Scientists. Further, the success stories of the entrepreneurs who had set up their enterprises based on ICAR-CIAE technologies and the plan, priorities and challenges before institute for the next five year plan were presented. Dr. Kanchan K Singh, ADG (FE) and Directors of different ICAR institutes present on the occasion greeted ICAR-CIAE on its 46th Foundation Day and lauded the significant achievements and contributions made by the institute at national and at international level in the area of agricultural engineering. The Chief Guest on the occasion, Dr. K Alagusundaram, DDG (Engg.) appreciated the significant contribution made by the institute for modernization of Indian agriculture and its effectiveness in bringing self-sufficiency in food-grains at national level. Dr. K Alagusundaram also delivered the 2nd Prof. A C Pandya Memorial Lecture wherein he stated that the future agricultural technologies would be an integration of multi-disciplinary sciences and engineering technologies including space, nano, robotics, precision farming and artificial intelligence while providing cost effective solutions for small, marginal and large farmers. He also congratulated the Scientists who received national level awards and recognitions and the progressive farmers, entrepreneurs and start-ups felicitated by the institute on this occasion. The programme ended with the vote of thanks presented by Shri Kumar Rajesh, CAO, ICAR-CIAE, Bhopal.

International Women's Day Celebration

International Women's Day was celebrated on 8 March, 2021 on the thematic area "Women leadership in **Agriculture: Entrepreneurship, equity and**

empowerment. A meet was organised by the Women's cell of the Institute along with KVK wherein 50 farm women participated. The role of nutrition and entrepreneurship in food processing for improving quality of life was delivered by Dr. Dipika Agrahar Murugkar. Products developed under the National Fellow project were also distributed to the farm women. On this occasion, a lady farmer was felicitated. A lecture was delivered by Dr. Ruma Bhattacharya, renowned psychiatrist on the theme of International Women's Day 2021 "**Choose to Challenge**": Mental health issues in the workplace and how to deal with it.

International Yoga Day

Seventh International Yoga Day was jointly organized by ICAR-CIAE, Bhopal and ICAR-CIPHET, Ludhiana, through virtual mode on 21 June 2021 from 7.00 to 9.00 am. This year's theme was "**Yoga for Well-being**".

The session was attended by 122 participants, which included staff and students of CIAE, CIPHET, doctors, senior officials, lawyers and engineers from different parts of the country. Yoga Guru Sri Sanjay Gurvekar, who has been teaching yoga for past 20 years conducted the yoga session and also provided information on benefits of yoga. The pranayama session was followed by a talk by Dr. Anju Soni, a leading gynaecologist, on women's health issues and remedy through regular exercise, yoga and meditation.

Dr. C R Mehta, emphasized the importance of yoga in this pandemic situation and urged regular practise for immunity and well-being. Yoga Guruji answered the queries raised by the participants. Dr. Nachiket Kotwaliwale, Director ICAR-CIPHET, Ludhiana shared his experience and benefits of yoga in his concluding remarks. A formal vote of thanks was delivered by Mr. Anil Handa, retired IAS officer. The session was organized by Dr. Debabandya Mohapatra, Principal Scientist through video conferencing.

Independence Day Celebrated

The 75th Independence Day of the nation was celebrated with pride and enthusiasm in which officers and employees of the institute participated. After the flag hoisting, Dr. C R Mehta, Director, ICAR-CIAE remembered the martyrs who sacrificed their lives for the freedom of the nation and called upon all to work

sincerely to make the country of their dreams. Further, he highlighted the current issues and challenges before the country at present in context to Indian agriculture and effect of COVID-19 pandemic on agriculture, in particular. He also briefed about major achievements of the Institute and staff of the Institute during last one year. The SOPs related to COVID-19 were followed during the event.

IMPORTANT COMMITTEES IN CIAE

Research Advisory Committee

1.	Dr. N C Patel, Former VC, AAU, Anand	Chairman
2.	Dr. K N Tiwari, Retd. Professor, IIT, Kharagpur	Member
3.	Dr. K K Singh, ADG (FE), ICAR, New Delhi	Member
4.	Dr. J S Mahal, Director of Extension Education, PAU, Ludhiana	Member
5.	Dr. B Panigrahi, Head, SWCE, CAET, OUAT, Bhubaneswar	Member
6.	Dr. G P Sharma, Professor, CTAE, Udaipur	Member
7.	Dr. C R Mehta, Director, ICAR-CIAE, Bhopal	Member
8.	Dr. S Gangil, PS & Head, AEP, ICAR-CIAE, Bhopal	Member Secretary

Institute Management Committee

1.	Director, ICAR-CIAE, Bhopal	Chairman
2.	Dr. K K Singh, ADG (Farm Engineering), Indian Council of Agricultural Research, New Delhi	Member
3.	Dr. H S Oberoi, Head, Division of Post Harvest Technology & Agricultural Engineering , ICAR-IIHR, Bengaluru	Member
4.	Dr. A K Singh, Principal Scientist, ICAR-IISR, Lucknow	Member
5.	Dr. P K Pathak, Principal Scientist & Head, Division of Farm Machinery & Post Harvest Technology, IGFRI, Jhansi	Member
6.	Dr. J J R Narware, Director, CFMTTI, Budni	Special Invitee
7.	Shri Mithilesh Kumar, SF&AO, IGFRI, Jhansi	Member
8.	Shri R Choudhary, Director, Directorate of Agricultural Engineering, Govt of Madhya Pradesh, Bhopal	Member
9.	Shri RK Verma, Additional Director (Engg), Department of Agriculture, Government of Bihar, Patna	Member
10.	Dr. S Patel, Prof & Head, Department of Agricultural Processing & Food engineering, IGKVV, Raipur	Member
11.	Shri P Singh, Pipliya Junarder Village, Berasiya Tehsil.	Member
12.	Shri S Manohar, Udaipur, Rajasthan	Member
13.	Chief Administrative Officer, ICAR-CIAE, Bhopal	Member Secretary

Institute Research Committee

1.	Director, ICAR-CIAE, Bhopal	Chairman
2.	Dr. S K Giri, I/c. PME Cell	Member
3.	All Scientists and Head of Divisions, CIAE, Bhopal	Member
4.	Dr. S Mandal, Scientist	Member Secretary

Institute Technology Management Committee

1.	Director, ICAR-CIAE, Bhopal	Chairman
2.	Dr. P C Bargale, PS & I/c. TTD	Member Technical Expert
3.	Dr. K N Agrwal, PC AICRP on ESA	Member Technical Expert
4	Dr. S Gangil, PS & I/c. AEP	Member
5.	I/c. PME Cell	Member
6.	Member Secretary IRC	Member
7.	Dr. S Srivastava, PS, ICAR-IISS Bhopal	External Member
8.	Dr. V Bhushana Babu, Sr. Scientist, AMD	Member Secretary & I/c. ITMC

Institute Joint Staff Council

1.	Director, ICAR-CIAE, Bhopal	Chairman
Official Side		
2.	Dr.K N Agrawal, PC (AICRP on ESA)	Member
3.	Dr. K Singh, Principal Scientist	Member
4.	Er. S Jadhav, Scientist	Member

5.	Dr. D K Jain, CTO	Member
6.	Finance & Account Officer	Member
7.	Chief Administrative Officer	Member Secretary (Official Side)

Staff Side

1.	Shri A K Pathak, STO	Member
2.	Shri A Meena, TA	Member
3.	Shri P V Sahare, LDC	Member
4.	Shri D K Barthare, PA	Member
5.	Shri A K Kumre, SSS	Member
6.	Shri K N Pal, Store Attendant	Member

Women Cell

1.	Dr. Dipika A Murugkar, Principal Scientist	Chairperson
2.	Ms. Swapnaja Jadhav, Scientist	Member
3.	Ms. Jolly John, TO	Member
4.	Ms. Bindu Prasad, Assistant	Member
5.	Mrs. Suruchi Bhagchandani, Assistant	Member
6	Ms. Swati Singh, AAO (Admin.)	Member
7.	Mrs. Kushal Suri, AAO (Rectt.), Ex. Officio	Member Secretary

PME Cell

1.	Dr. S K Giri, Principal Scientist	In charge-PME Cell
2.	Dr. R K Singh, Principal Scientist	Member
3.	Dr. V Bhushana Babu	Member
4.	Dr. S Mandal, Senior Scientist	Member
5.	Dr. A Kate, Scientist	Member
6.	Dr. A Khadatkar, Scientist	Member
7.	Dr. A P Pandirwar, Scientist	Member

Committee for Prevention of Sexual Harassment of Women at Workplace

1.	Dr. Dipika A Murugkar, Principal Scientist	Chairperson
2.	Dr. Samlesh Kumari, Scientist	Member
3.	Mrs. Deepika Shende Channe, ACTO	Member
4.	Mrs Manju Lohani, Assistant	Member
5.	Dr. K Bharati, Principal Scientist	Member – ICAR-IISS
6.	Mrs. Kushal Suri, Assistant Administrative Officer	Member Secretary

Hindi Rajbasha Committee

1.	Dr. C R Mehta, Director	Chairman
2.	Dr. K N Agrawal, Project Coordinator, ESA	Member
3.	Dr. K P Singh, Principal Scientist	Member
4.	Shri Kumar Rajesh, CAO	Member
5.	Shri R Dubey, F&AO	Member
6.	Dr. S P Singh, CTO	Member Secretary

Board of Studies (PG School)

1.	Director, ICAR-CIAE, Bhopal	Chairman and Professor
2.	Dr. S Gangil, Head AEP	Member
3.	Dr. K N Agrawal, PC, AICRP on ESA	Member
4.	Dr. K Singh, Principal Scientist	PG School Coordinator
5.	Dr. K P Singh, Principal Scientist	Member
6.	Dr. S K Giri, Principal Scientist	Member
7.	Dr. D Mohapatra, Principal Scientist	Member

8.	Dr. V Bhushana Babu, Senior Scientist	Member
9.	Dr. Y A Rajwade, Scientist	Member
10.	Mr. A Patel, PhD III year Student	Student Representative

Institute Technology Release Committee

1.	Director, ICAR-CIAE, Bhopal	Chairman
2.	PCs of AICRPs (FIM, EAAI, HAES, ESA)	Member
3.	HoDs (AMD/AEP/APPD/IDED/TTD)	Member
4.	I/c. PME Cell	Member
5.	PI & Co-PI of the Project or Technology	Member
6.	Member Secretary, IRC	Member Secretary

Ongoing Research Projects during 2021-22

AMD

Project No.	Title	Investigators
782	Development of drip lateral and plastic mulch layer -cum-planter	C P Sawant Abhijit Khadatkar A P Magar B B Gaikwad
815	Mechanization package for garlic cultivation on raised beds	Dilip Jat S Imran
870	Design and development of residue cleaner mechanism for no-till seed drill	Manish Kumar C P Sawant
838	Mechanization of selected operations in Litchi cultivation	Sweeti Kumari Manish Kumar Ramesh Kumar Sahni Sanjay Singh (NRC Litchi)
856	Deep Learning Based Framework for Abiotic Stress Phenotyping in Field Crops	N S Chandel S K Chakraborty Y A Rajwade Dilip Jat
816b	Design and development of induction based air assisted electrostatic sprayer	Bikram Jyoti A P Pandirwar
816c	Development of tractor operated fertilizer applicator for grape vineyard	D S Thorat Bikram Jyoti Ajit Magar
858	Model farm machinery package for major horticulture crops of India	Karan Singh Balaji Nandede Bikram Jyoti R S Singh
854	Participatory promotion of climate resilient agriculture machinery in selected village cluster of MP	Manoj Kumar (Stat.) K P Singh R K Singh Ramadhar Singh
855	Integrating tillage, traffic, crop residue and crop rotation management practices in prevailing cropping system for facilitating conservation agriculture mechanization in vertisols	Uday R Badegaonkar K P Singh Mukesh Kumar Manish Kumar Manoj Kumar (Stat) Imran S
868	Evaluation of spray droplet deposition characteristics of unmanned aerial vehicle	S P Kumar Dilip Jat Manoj Kumar (FMP)

871	Development of unmanned ground vehicles for agriculture fields	Manoj Kumar Shashi Rawat
882	Development of camera assisted hydraulically operated pneumatic fruit picking system	Ajay Kumar Roul Bikram Jyoti
883	Deep learning based computer vision techniques for yield estimation of mandarin oranges	Subeesh A S P Kumar
893	Development of brush type cotton harvester	A P Pandirwar Ajay Roul Balaji Nandede G Majumdar, CICR
894	Development of autonomous weeder for wide spaced field crops	Abhijit Khadatkar
895	Impact assessment of selected agricultural machinery and post-harvest technologies	K P Saha V Bhushanababu Dushyant Singh T Senthilkumar
902	Development of portable in-situ soil gas flux measurement system	H S Pandey Manoj Kumar
906	Robotic transplanter for plug-type vegetable seedlings	Abhijit Khadatkar C P Sawant A P Magar
907	Development of sensor-based variable-rate nutrient applicator	N S Chandel Dilip Jat Subeesh A
765	Development of transplanter for onion seedlings	A P Magar B B Gaikwad A P Pandirwar
839	Development and promotion of CA machinery	Dushyant Singh N S Chandel A K Vishwakarma (IISS, Bhopal)
869	Development of automatic spraying system for polyhouse	Dilip Jat S P Kumar R A Rajwade
872	Survey of agricultural accidents in Madhya Pradesh for the year 2020-21 and generation of data bank	V Bhushana Babu R R Potdar M B Tamankar
824	Determination of water stress indices using spectral reflectance and thermal imaging in field crops.	N S Chandel Y A Rajwade
836	Development of a lab based robotic transplanter for plug-type vegetable seedlings	A. Khadatkar A P Pandirwar
816(a)	Development of side trencher-cum-FYM applicator for grapes orchard	Abhijit Khadatkar C P Sawant Y Verma (NRC Grapes)
823	Development of tractor drawn five row weeder for onion	A P Pandirwar R R Potdar
814	Mechanization package for pigeon pea cultivation	B M Nandede Dilip Jat
795	Development of tractor operated drainage trencher for laying sub-surface pipes	B M Nandede R D Randhe A M Waghaye
811	Development of mechanized CA model farm for major cropping systems in vertisol of Central India	C P Sawant K P Singh R S Singh
857	Development of image based hand held device for diseases identification in soybean	Manoj Kumar N S Chandel Sanjeev Kumar (IISR, Indore)

791	Package of machinery for orchard crops suitable for mini tractors	S P Kumar B M Nandede A K Roul
815	Mechanization package for garlic cultivation on raised beds	Dilip Jat S Imran

APPD

Project No.	Title	Investigators
873	Development of android App for business promotion of selected fruit processing crops	Karan Singh S K Chakraborty
863	Development of user-friendly image based embedded system for automated packing line for horticultural produce	S K Chakraborty Subeesh A
860	Process Technology for production of plant by-products based solid nutrient culture media (s) for food applications	M K Tripathi S K Giri R M Srivastva (MANIT, Bhopal)
884	Development of sensor enabled storage system for potato	Pravitha M Adinath Kate
885	Development of grain handling system with IR-UV based in-situ surface disinfestation	Adinath Kate Dilip Pawar
909	Supplementation of soy and multigrain snack products to improve the nutritional status and create employment for farm women of MP	D Agrahar Murugkar
910	Development of small scale processing unit for dried tomato products	Pravitha M D Agrahar Murugkar
911	Development of sensor based multi-pass cleaner for pulses	S K Chakraborty Adinath Kate Subeesh A

CESPU

Project No.	Title	Investigators
842	Development of process technology for soymilk based symbiotic chocolate	Samlesh Kumari
859	Development of soy-based nano-composite bio-functional edible and packaging film	Samlesh Kumari A Kumar
861	Development of kit for identification of soy protein in paneer and milk (lateral flow kit)	P Chandra
874	Design and development of a continuous edible film making machine	Ajesh Kumar V S Mangaraj
886	Status of soybean processing units in India and providing technical guidance for effective enterprise	Punit Chandra S Mangaraj
896	Development of process technology for soy based multifunctional probiotic chocolate milk powder	Samlesh Kumari Dibyakanta Seth, NIT Rourkela

AEPD

Project No.	Title	Investigators
846	Development of process and technology for value added products from segregated bio-crude	S Gangil V K Bhargav Sandip Mandal S Suresh, MANIT
843	System for production of enriched biochar from crop residues	Sandip Mandal C Maheshwari A K Shukla, IISS S K Behera, IISS

864	Development of Process for Bio-methane Generation from Baled Paddy Straw	Swapnaja Jadhav P C Jena Chirag Maheswari
897	Development of multi-utility e-vehicle for agricultural operations	P C Jena Ankur Nagori V K Bhargav
914	Energy inflow and outflow assessment of soybean and wheat cropping system in selected village of MP	P C Jena H Wakudkar
915	IoT based crop residue availability assessment in the state of MP	V K Bhargav Sandip Gangil
916	Development of automated gasifier based gen-set	Sandip Mandal
917	Development of biomass based hot air generation system	Ankur Nagori
918	Development of insulating material from crop residues and their pyrolytic products	Ankur Nagori V K Bhargav
844	Development of portable gasifier with inbuilt tar cracking system	Sandip Mandal P C Jena
805	Solar powered prime mover for spraying and weeding operations	P C Jena A Nagori
845	Development of crop residue hydrolysate based micro algae production and byproduct utilization	Swapnaja K Jadhav Samlesh Kumari Chirag Maheswari
847	Energy assessment and crop residues management for fuel supply chain of power plants	V K Bhargav S Gangil
887	Valorisation of lignocellulosic biomass to bioethanol through efficient fractionation of lignin	Chirag Maheshwari Sandip Mandal

IDED

Project No.	Title	Investigators
850	Development of automatic self-cleaning filter for micro irrigation system	Mukesh Kumar C K Saxena
876	Development of CIAE drainage system plan for storm rainfall	R K Singh
849	Development and evaluation of IoT based smart irrigation system for field crops in vertisols	C D Singh Mukesh Kumar A M Waghaye
875	Design and development of mole plough for undulating field condition in Vertisols	R K Singh, Ramadhar Singh Ajita Gupta
877	Development of digital weighing type lysimeter for irrigation scheduling of different crops	Ajita Gupta R K Singh
866	Design and development of floating axial flow pump for small farms	Mukesh Kumar C D Singh
921	Unmanned Aerial Vehicle based Multispectral imagery and Data Driven Techniques for Irrigation Scheduling and Water Productivity in Field Crops	Y A Rajwade N S Chandel K V R Rao P Sujith (IISER)
923	Development of AI/IoT Based intelligent Irrigation System for Field Crops	C D Singh Mukesh Kumar Y A Rajwade
828	Development and testing of surface and subsurface drip lateral retrieval systems	C K Saxena K V R Rao

TTD

Project No.	Title	Investigators
878	FLD on package of machinery for small millet crops	U C Dubey M B Tamhankar
888	Identification of potential CIAE Technologies suitable for selected States and their commercial prospects	M B Tamhankar U C Dubey

RC Coimbatore

Project No.	Title	Investigators
853	Development of millet popping machine	S Balasubramanian Dawn C P Ambrose
889	Development of tractor operated raised bed former cum onion set planter for multiplier onion	T Senthilkumar Syed Imran
833	Chitosan coated bags for storage of selected food grains	Sadvatha, R H
879	Development of continuous feed banana fibre extraction equipment (Collaborative project with ICAR National Research Centre for Banana, Trichy)	Ravindra Naik P S Kumar, NRCB
890	Development of three in one motorised tool for ablation and harvesting of oil palm Fresh Fruit Bunch (FFB) (Collaborative project with ICAR Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh)	Ravindra Naik S Shivashankar MV Prasad T Vidhan Singh
891	Development of Cashew fruit collector and nut separator (Collaborative project with ICAR Directorate of Cashew Research Puttur, Karnataka)	Ravindra Naik Manjunatha K Balasubramanian D
899	Development and evaluation of FCV tobacco leaves stringing machine	Sadvatha RH S K Aleksha Kudos T Kiran Kumar (CTRI)
900	Development of pulsed uv light system for fresh fruits and vegetables	Sadvatha RH
901	Development of self-propelled track type vehicle for small farms	Syed Imran S T Senthilkumar
880	A multi-dimensional study on Zero-Till Drill adoption in Southern India	M M Selvan R Senthil Kumar
881	Development of unmanned rice transplanter	Syed Imran T Senthil Kumar
852	Establishing value chain for chilli processing	Dawn C P Ambrose Ravindra Naik
892	Development of electro-magnetic seed metering system in seed drills and planters	M Muthamil Selvan
829	Package of machinery for baby corn processing	S K A Kudos R H Sadvatha
834	Adoption of transplanter, stringing machine and hybrid energy curing barn for tobacco leaves	Sadvatha R H Aleksha Kudos T Senthilkumar
832	Development of Tractor operated whole cane harvester suitable for small farmers	T Senthil kumar T Arumuganathan, (SBI) A K Singh (IISR, Lucknow) M K Singh (IISR, Lucknow)

SCSP

Project No.	Title	Investigators
898	Technology outreach and agricultural engineering interventions for improving the rural livelihoods of SC BPL beneficiary of selected villages of Madhya Pradesh and Tamil Nadu	S Mangaraj R Senthil Kumar Rahul Potdar P C Jena Dilip Pawar Sweeti Kumari
867	Technology dissemination and agricultural mechanization in selected villages of Madhya Pradesh for Increased Productivity and Income generation	S Mangaraj Ramadhar Singh K P Saha Manoj Kumar (Stat) Rahul Potdar P C Jena Mukesh Kumar Dilip Pawar Sweeti Kumari M K Tripathi R Senthil Kumar Aleksha Kudos

Externally funded projects

S.No.	Title of The Project	Investigator(s)	Funding agency
EXT 1	Development of soy multigrain nutritionally rich functional foods for children	D A Murugkar	National Fellow, ICAR
EXT 3	Development of Automated Soil Nutrient Sensing System	P S Tiwari Ajay Roul R K Sahni Vijay Kumar	NASF, ICAR
EXT 4	Post-harvest management of medicinal root crops	D Mohapatra Dilip Pawar	NMPB, Ministry of AYUSH
EXT 6	Mainstreaming Gender and Empowerment through Women Friendly Farm Mechanization Package in Tribal areas of Tamil Nadu	R Senthil Kumar M M Selvan S Balasubramanian	DST, New Delhi
EXT-8	Engineering input in establishment of biotech kisan hub	Dushyant Singh B M Nandede D S Thorat	DBT, New Delhi
EXT 9	Development of a sensing system for safe management of potato, onion and tomato in storage	D Mohapatra Adinath Kate M K Tripathi	NASF, ICAR
EXT 10	Studies on thermal degradation of crop residues for kinetics, bio-polymeric transitions and value added products	S Gangil V K Bhargav	NASF, ICAR
EXT-12	Design and development of an air assisted recycling tunnel sprayer for horticultural crops	Bikram Jyoti A K Roul Manoj Kumar (Stat.)	DST, New Delhi
EXT-13	Expansion of activities of biotech kisan hub in seven aspirational districts in Madhya Pradesh	B M Nandede Dushyant Singh	DBT, New Delhi
EXT 14	Instrument for rapid detection of aflatoxin-b1 in cereal grains and oilseeds: hyper afla	Subir K Chakraborty M K Tripathi	DST, New Delhi

EXT 15	Development of Nano Sensor and its application through cloud based network for real time irrigation to soil and plant (NASF project)	C D Singh N S Chandel	NASF, ICAR

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