ANNUAL REPORT

2024-25

Indian Council of Agricultural Research

Department of Agricultural Research and Education

Ministry of Agriculture & Farmers Welfare

Government of India, New Delhi

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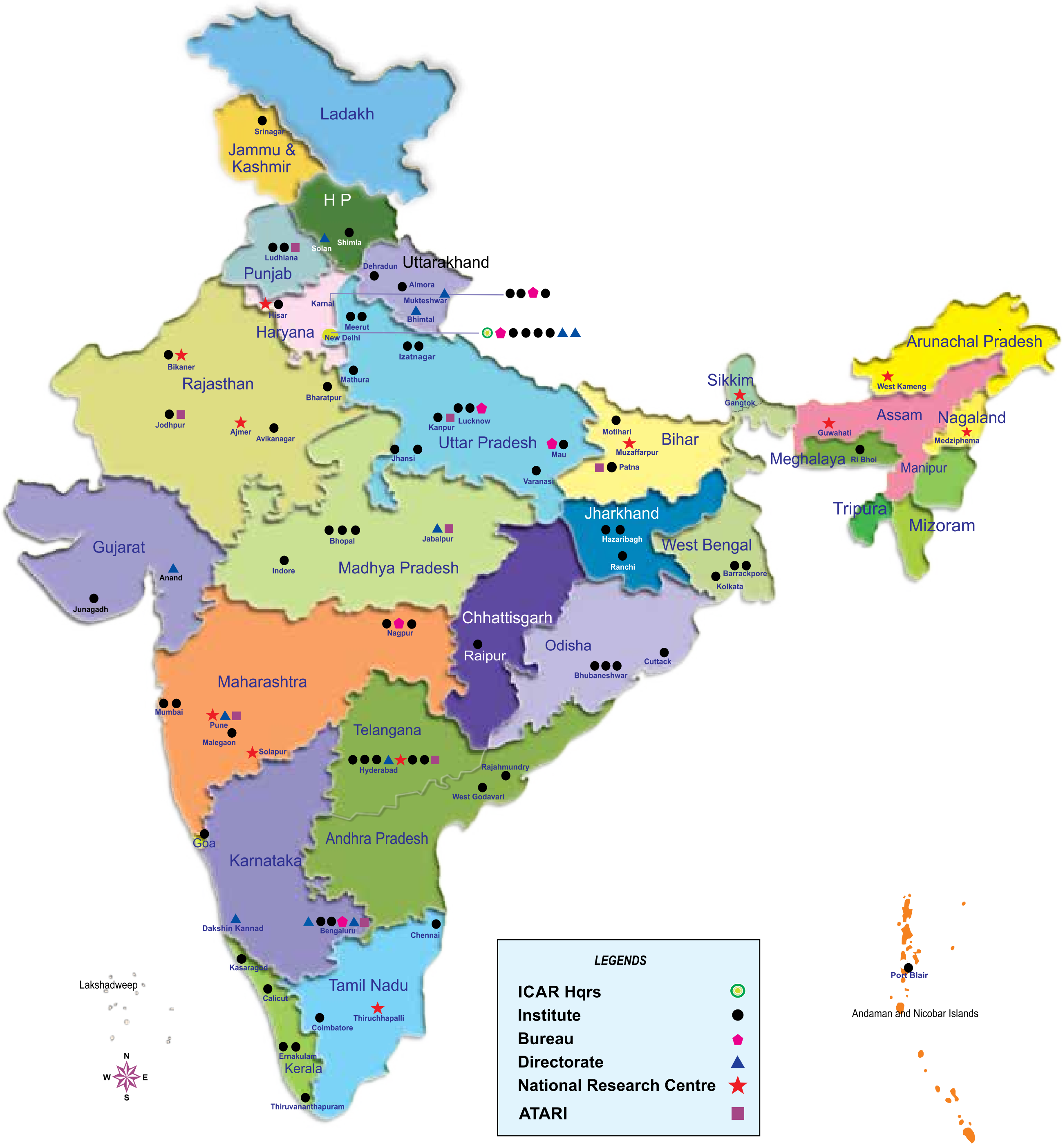
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates, National Research Centres and ATARIs



*Map not to scale

• 74 Research Institutes • 6 Bureaux • 11 Directorates • 11 National Research Centres • 11 ATARIs

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भाकृअनुप
ICAR

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Foreword

कृषि, भारत के लिए ही नहीं, वरन संपूर्ण विश्व के लिए अति आवश्यक है। भारत जैसे अधिक जनसंख्या वाले देश में अधिकांश आबादी अपनी खाद्य आवश्यकताओं की पूर्ति के लिए अपनी आजीविका हेतु कृषि क्षेत्र पर ही निर्भर है। कृषि हमारी अर्थव्यवस्था का मेरूदंड है और किसान उसकी आत्मा हैं। माननीय प्रधानमंत्री जी के नेतृत्व में हमें वर्ष 2047 तक विकसित भारत का निर्माण करना है और विकसित भारत के लिए विकसित खेती हमारा लक्ष्य है। कृषि को लाभकारी उद्यम बनाने के लिए सरकार की छह सूत्रीय रणनीति है –(i) उत्पादन बढ़ाना (जिसके लिए भाकृअनुप लगातार अनुसंधान करती है), (ii) उत्पादन की लागत घटाना, (iii) फसल के उचित दाम देना, (iv) नुकसान हो जाए तो भरपाई करना, (v) खेती का विविधीकरण और (vi) धीरे–धीरे प्राकृतिक खेती की ओर बढ़ना।

भारतीय कृषि अनुसंधान परिषद की गतिविधियां और अनुसंधान मुख्य रूप से भुखमरी, गरीबी उन्मूलन, टिकाऊ कृषि प्रथाओं को बढ़ावा देने, पर्यावरणीय स्वास्थ्य में सुधार करने और किसानों के लिए समान विकास सुनिश्चित करने, तथा विशेष रूप से ग्रामीण भारत में राष्ट्रीय और वैश्विक टिकाऊ विकास लक्ष्यों का समर्थन करने पर केंद्रित हैं। यही कारण है कि आज हम अपने देश की खाद्य आवश्यकताओं की ही पूर्ति नहीं कर रहे, बल्कि कई देशों में फल, सब्जियां निर्यात कर उन्हें सहयोग कर रहे हैं। भविष्य में हमारा प्रयास है कि लोगों को ऐसा शुद्ध आहार मिले, जो मानव शरीर के लिए भी उपयोगी हो और धरती का स्वास्थ्य भी बना रहे।

दुनिया की खाद्य आवश्यकता की पूर्ति करने के लिए यह आवश्यक है कि उत्पादन बढ़े और उत्पादन बढ़ाने के लिए सबसे महत्वपूर्ण है बीज, जो गुणवत्तापूर्ण होना चाहिए। बीज, खेती के प्राण हैं और अच्छे बीजों से उत्पादन 20 प्रतिशत तक बढ़ाया जा सकता है। इस क्षेत्र में भारतीय कृषि अनुसंधान परिषद निरंतर प्रयासरत है। इसी कड़ी में 11 अगस्त, 2024 को भारतीय कृषि अनुसंधान संस्थान (IARI) में प्रधानमंत्री श्री नरेंद्र मोदी जी के कर–कमलों से बीजों की 109 किस्में जारी की गई थी, जो अधिक पैदावार देने वाली, जलवायु–अनुकूल, कम पानी और कम समय में भरपूर फसल उत्पादन करने वाली हैं। माननीय प्रधानमंत्री जी ने इस कार्यक्रम के दौरान किसानों और वैज्ञानिकों से भी बातचीत की। इस पहल का उद्देश्य कृषि उत्पादकता और किसानों की आय को बढ़ाना था। कुल 61 फसलों से संबंधित इन किस्मों को भारतीय कृषि अनुसंधान परिषद ने विकसित किया है। इनमें 34 खेत फसलें और 27 बागवानी फसलें शामिल हैं। सभी किस्में पोषणयुक्त हैं, जिन्हें जलवायु एवं क्षेत्र के अनुकूल विकसित किया गया है। इनमें धान की एक ऐसी किस्म विकसित की गई है जिसमें 20% कम सिंचाई की आवश्यकता होगी और इसमें रोपाई करने की आवश्यकता नहीं है। गेहूँ की तरह ही इसकी बुआई कर सकते हैं। उन्नत एवं विकसित बीज यदि किसानों को मिल जाएँ तो हम दुनिया का फूड बास्केट बन सकते हैं।

अब समय आ गया है कि भारतीय कृषि अनुसंधान परिषद की पिछले वर्षों में अर्जित की गई मुख्य उपलब्धियों का विश्लेषण किया जाए और आगामी 5 वर्षों के लक्ष्य तथा मार्गदर्शिका तय की जाए। अनुसंधानकर्मियों का कार्य केवल प्रयोगशाला तक ही सीमित न रहे बल्कि उसे किसानों तक भी पहुंचाया जाए (लैब टू लैंड यानि विज्ञान से किसान)। इसके साथ ही ऐसी तकनीक विकसित करनी चाहिए जिससे कम पानी में ज्यादा सिंचाई हो सके।

रिपोर्टाधीन वर्ष के दौरान, भारतीय कृषि अनुसंधान परिषद की उपलब्धियां सराहनीय हैं। इस वर्ष के दौरान कुल 524 किस्मों/संकर किस्मों को खेती प्रायोजन के लिए अधिसूचित किया गया और व्यावसायिक खेती के लिए जारी किया गया। इनमें 34 जैव प्रबलित किस्में और 79 अन्य किस्में शामिल हैं, जो विभिन्न अजैविक दबावों जैसे सूखा, पानी की कमी, बाढ़, जलभराव, लवणता, क्षारीयता, कम तापमान आदि से निपटने के लिए अनुकूल हैं। फसलों में कुल प्रजनक बीज उत्पादन 1,06,397.6 क्विंटल था, जिनमें प्रमुख हिस्सा अनाज फसलों का है। सभी वर्गों सहित गुणवत्तापूर्ण बीज का कुल उत्पादन 4,28,046.0 क्विंटल रहा। इसके अलावा, 103.9 लाख रोपण सामग्री और 10.4 लाख ऊतक संवर्धित पादप फुदकों का उत्पादन किया गया। केंद्रीय उप–समिति द्वारा 75 बागवानी फसलों में 189 किस्मों की पहचान की गई, जिन्हें भारत सरकार द्वारा फसल मानक, जारी करने और बागवानी फसलों की किस्मों को अधिसूचना हेतु अनुमोदित किया गया।

भारतीय कृषि अनुसंधान परिषद की पशुपालन, प्रजनन प्रौद्योगिकियों और आनुवंशिक सुधार में प्रगति से भारत में दुग्ध उत्पादन, पशु स्वास्थ्य और प्रजनन क्षमता में सुधार हुआ। इस अवधि के दौरान सिंथेटिक फ्रीजवाल गाय की नस्ल विकसित की गई, जो प्रति दुग्धस्रवण अवधि में 7,000 किलोग्राम दूध देती है। गिर, कांकरेज और साहीवाल नस्लों के आनुवंशिक सुधार से 53.71% दूध उत्पादन में वृद्धि हुई और 16.73% प्रजनक गायों में प्रथम बार नवजात बछड़ा/बछड़ी जनने की उम्र में कमी आई। जीनोम फेरबदल में MSTN नॉकआउट बछड़ा और CRISPR तकनीक से लिंग–निर्धारित भ्रूण उत्पादन में प्रगति हुई। भैंसा/सांड प्रजनन क्षमता चिप विकसित की गई, और रिकॉम्बिनेंट FSH और LH हार्मोन का उत्पादन किया गया। मुर्रा भैंस में 305 दिनों का दुग्धस्रवण उत्पादन 2,665 किलोग्राम तक पहुंचा, जो 66.35% वृद्धि दर्शाता है। इसी प्रकार भेड़ सुधार परियोजना ने 146 प्रजनकों और 13,832 भेड़ों को कवर किया।

भारत में मत्स्य पालन को बढ़ावा देने, खाद्य सुरक्षा को मजबूत करने और सतत मछली पालन को बढ़ावा देने के लिए कई पहल की गई हैं। इसके अंतर्गत राष्ट्रीय रैंचिंग कार्यक्रम के तहत गंगा नदी में इंडियन मेजर कॉर्प और महसीर जैसी देसी मछलियों की प्रजातियों को पुनः स्थापित किया गया है, और पश्चिम बंगाल, उत्तर प्रदेश, बिहार, झारखंड और उत्तराखंड जैसे राज्यों में 49.1 लाख आंगुलिक मत्स्य को छोड़ा गया।

जैसा कि वैश्विक रुझान सटीक और डिजिटल खेती की ओर बढ़ रहा है, भारतीय कृषि अनुसंधान परिषद भारत में उन्नत कृषि प्रौद्योगिकियों को शुरू करने और अपनाने में अग्रणी है। भारतीय कृषि अनुसंधान परिषद का दृष्टिकोण खेती को अधिक कुशल, टिकाऊ और सुलभ बनाने पर केंद्रित है, जिसमें मशीनीकरण, फसल निगरानी और डेटा विश्लेषण के लिए डिजिटल उपकरणों का उपयोग शामिल है। इनमें एक इमेज–आधारित नाइट्रोजन

एप्लीकेटर शामिल है, जो फसल के दबाव के आधार पर उर्वरक को समायोजित करता है, और एक बहुउद्देशीय मानवरहित वाहन जो छोटे खेतों पर बुआई और निराई के लिए उपयोग किया जाता है। इसके अलावा, नई तकनीकों जैसे मशीनीकरण, बागवानी, ड्रिप सिंचाई, ग्रीनहाउस, पॉलीहाउस और हाइड्रोपोनिक्स को बढ़ावा दिया जा रहा है। भारतीय कृषि अनुसंधान परिषद ने सटीक कृषि को बढ़ावा देने के लिए मृदा सेंसर, जीपीएस–समर्थित उपकरण और फसल स्वास्थ्य की निगरानी के लिए ड्रोन जैसे उपकरणों का उपयोग किया है। इस तरह की परियोजनाओं ने किसानों को पानी, उर्वरक और कीटनाशकों को सही तरीके से लागू करने में मदद की है, जिससे लागत और पर्यावरणीय प्रभाव कम हुआ है। यह मानते हुए कि भारतीय खेतों का एक बड़ा हिस्सा छोटा और विभाजित है, भारतीय कृषि अनुसंधान परिषद ने छोटे किसानों के लिए प्रभावी और किफायती कृषि मशीनरी के विकास पर ध्यान केंद्रित किया है। कृषि संचालन को विभिन्न चरणों में सुधारने के लिए कई प्रकार के सेंसर–आधारित, रोबोटिक और यांत्रिक उपकरण विकसित किए गए हैं।

भारतीय कृषि अनुसंधान परिषद ने कृषि उच्च शिक्षा के भविष्य को सुधारने में अपनी महत्वपूर्ण भूमिका को निरंतर बनाए रखा है। इस वर्ष, छठी डीन समिति रिपोर्ट में अनुशंसित 13 कृषि और संबंधित विषयों में स्नातक पाठ्यक्रम का पुनर्निर्माण किया गया, जो राष्ट्रीय शिक्षा नीति 2020 के अनुसार है। यह पाठ्यक्रम लचीला है, जिसमें कई प्रवेश और निकासी बिंदु हैं और रोजगार क्षमता बढ़ाने के लिए कौशल प्रशिक्षण और इंटर्नशिप के माध्यम से अकादमिक बैंक ऑफ क्रेडिट (ABC) को एकीकृत करता है। हमारे युवा ऊर्जा से भरे हैं, उनके पास विजन और अपार क्षमता है। हमारे युवा स्टार्टअप के क्षेत्र में देश–विदेश में खूब नाम कमा रहे हैं। एग्रीटेक स्टार्टअप्स की बढ़ती संख्या यह दर्शाती है कि हमारे किसान नई तकनीक, नवाचार और उद्यमिता से जुड़ रहे हैं। कृषि के आधुनिकीकरण के लिए कृषि और किसान कल्याण मंत्रालय, इन स्टार्टअप को प्रोत्साहित करने के साथ ही उन्हें आवश्यक सहयोग और संसाधन भी उपलब्ध करवा रहा है।

कृषि विज्ञान केंद्रों ने 6,028 कृषि तकनीकी विकल्पों का मूल्यांकन किया, जिसमें 6,895 परीक्षणों में 1,758 किस्मों का मूल्यांकन किया गया। पशुपालन मूल्यांकन में पोषण, रोग और चारा प्रबंधन पर ध्यान केंद्रित किया गया जिसमें 5,719 परीक्षण किए गए। क्लस्टर अग्रिम पंक्ति प्रदर्शनों ने दलहनी और तिलहनी फसलों पर क्रमशः 20,206.84 हेक्टेयर और 26,220 हेक्टेयर क्षेत्र कवर किया, जिससे दलहन में 34.36% और तिलहन में 29.40% उत्पादन की वृद्धि हुई। इसमें 20 लाख से भी अधिक प्रतिभागियों ने 65,235 प्रशिक्षण कार्यक्रमों में भाग लिया जिसमें 49,534 पाठ्यक्रम किसानों और महिला किसानों के लिए थे। इसके अतिरिक्त 10,651 ग्रामीण युवाओं ने कौशल विकास कार्यक्रम में भाग लिया और 9.33 लाख विस्तार गतिविधियाँ आयोजित की गईं जिससे 395 लाख प्रतिभागियों को लाभ हुआ। आर्या परियोजना ने 16,952 युवाओं को प्रशिक्षित किया, जबकि निक्रा परियोजना ने 49,278 किसानों को जलवायु–अनुकूल कृषि के बारे में जानकारी दी। वहीं नारी (NARI) कार्यक्रम ने 13,614 पोषण वाटिका स्थापित कीं जिससे 15,774 परिवार लाभान्वित हुए। भविष्य के लिए यह सुझाव है कि कृषि विज्ञान केंद्रों द्वारा प्रत्येक महीने विकसित की जा रही नई किस्मों के लाभ के बारे में किसानों को बताया जाना चाहिए ताकि खेती की लागत में कमी आ सके।

नारी सशक्तिकरण की दिशा में सरकार अत्यधिक संवेदनशील है। भाकृअनुप की प्रमुख गतिविधियों में लैंगिक संवेदनशीलता, क्षमता निर्माण और प्रौद्योगिकी–आधारित शारीरिक श्रम में कमी शामिल हैं। परिषद द्वारा महिला किसानों को ड्रोन प्रौद्योगिकी में प्रशिक्षण देकर डिजिटल कृषि को बढ़ावा दिया जा रहा है और पोषण–स्मार्ट गांव कार्यक्रम के माध्यम से कुपोषण को दूर करने एवं खाद्य सुरक्षा को सुनिश्चित किया जाता है। सरकार द्वारा पूरे देश में 3 करोड़ लखपति दीदी बनाने का लक्ष्य निर्धारित किया गया है। अब तक महिलाओं के स्वयं सहायता समूह तथा अन्य संस्थानों द्वारा 1.15 करोड़ बहनों को लखपति दीदी बनाया गया है।

यह धरती केवल मनुष्यों के लिए ही नहीं बनी है बल्कि यह कीट–पतंगों जैसे सभी जीवों के लिए बनी है। यह हर्ष की बात है की भारत वार्षिक 332 मिलियन टन खाद्यान्न उत्पादित करता है जो वैश्विक खाद्य व्यापार में महत्वपूर्ण योगदान देता है। इसके निर्यात से 50 मिलियन डॉलर की कमाई भी होती है लेकिन यह सफलता साथ में मृदा के स्वास्थ्य को लेकर चिंतायें भी लाई है। यह समय की मांग है कि हमें प्राकृतिक खेती की तरफ बढ़ना है जिसमें कीटनाशकों के अनियन्त्रित प्रयोग को रोकने की जरूरत है। इससे उत्पादन में मूल्यवर्धन होगा। प्राकृतिक कृषि मिशन के तहत उत्पादन की मात्रा को बरकरार रखते हुए धीरे–धीरे हमें प्राकृतिक खेती की ओर बढ़ना होगा एवं आगामी समय में इसका लाभ सभी को मिलेगा। प्राकृतिक खेती के साथ–साथ जैविक खेती के प्रति किसानों ने जैविक खाद्य उत्पादों का इस्तेमाल बढ़ा दिया है। पोषणयुक्त अनाज की मांग में वृद्धि हो रही है। श्रीअन्न की ओर झुकाव इसका प्रमुख उदाहरण है। भारत में बहुत सी परंपरागत किस्में हैं जिनके बीजों को सहेज कर रखने की अत्यंत आवश्यकता है। कृषि क्षेत्र से जुड़े वैज्ञानिकों और किसानों को एकत्र होकर समस्याओं का समाधान करना चाहिए। इसके लिए यह भी जरूरी है कि कृषि क्षेत्र से जुड़ी जानकारियां केवल अंग्रेजी भाषा में ही सीमित न रहें वरन इसे भारत की विभिन्न भाषाओं में भी प्रकाशित करना आवश्यक है।

उपरोक्त उल्लेखनीय उपलब्धियों के साथ, मुझे भाकृअनुप वार्षिक रिपोर्ट (2024–25) प्रस्तुत करते हुए अत्यधिक प्रसन्नता हो रही है, जिसमें कृषि अनुसंधान, शिक्षा और विस्तार की कई गतिविधियों पर प्रकाश डाला गया है। मुझे, कृषि क्षेत्र में राष्ट्रीय प्राथमिकताओं और भाकृअनुप के कार्यक्रमों के बीच प्रभावी एकरूपता को देखकर खुशी हो रही है, विशेष रूप से जलवायु परिवर्तन, लघु किसानों की लाभप्रदता और टिकाऊ कृषि पद्धतियों से संबंधित वर्तमान चुनौतियों का सामना करने में। इस वर्ष की गई पहल निस्संदेह भविष्य में फल देगी और राष्ट्र में कृषि को एक लाभदायक पेशे के रूप में सुनिश्चित करके अमृतकाल में वैश्विक आर्थिक शक्ति बनने के लक्ष्यों को प्राप्त करने में सकारात्मक योगदान देगी। आशा है कि पाठक इस सामग्री को उपयोगी पाएंगे और हमें अपने रचनात्मक विचार प्रदान करेंगे ताकि हम कृषि अनुसंधान और मानव संसाधन विकास पर कार्यक्रमों में सुधार ला सकें।

मुझे पूर्ण विश्वास है कि भाकृअनुप वार्षिक रिपोर्ट 2024–25 सभी हितधारकों को भारत में कृषि अनुसंधान और शिक्षा के लिए भविष्य की रणनीतियों की रूपरेखा तैयार करने में मदद करेगी।

(शिवराज सिंह चौहान)
अध्यक्ष, भाकृअनुप सोसायटी

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Indian Council of Agricultural Research

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The Mandate of the Indian Council of Agricultural Research

- Plan, Undertake, Coordinate and Promote Research and Technology Development for Sustainable Agriculture.
- Aid, Impart and Coordinate Agricultural Education to enable Quality Human Resource Development.
- Frontline Extension for Technology Application, Adoption, Knowledge Management and Capacity Development for Agri-based Rural Development.
- Policy, Cooperation and Consultancy in Agricultural Research, Education and Extension.

1.
Overview

The Indian Council of Agricultural Research (ICAR) has consistently played a pivotal role in driving innovations that enhance productivity, resilience, and sustainability in Indian agriculture. It has been a pioneer in introducing and adapting advanced agricultural technologies in India. ICAR's approach has focused on making farming more efficient, sustainable, and accessible for farmers of all scales. While ICAR's contributions to food production are substantial, there are future challenges that demand innovative solutions. Climate change, soil degradation, and resource scarcity remain prominent threats to sustainable agriculture. To address these, ICAR has outlined strategic plans focused on advancing research, enhancing resource-use efficiency, and promoting crop diversification. The salient achievements of the Council during 2024-25 are presented below.

Crop Improvement and Management: During the reporting period, 524 varieties and hybrids were notified and released for commercial cultivation, including 34 biofortified varieties and 79 varieties developed to withstand abiotic stresses such as drought, water scarcity, floods, waterlogging, salinity, sodicity, and low temperatures. Precision breeding tools, particularly marker-assisted selection, were used to develop 10 trait-specific varieties. Among the varieties released, 246 high-yielding cereal varieties were introduced, including 126 of rice, 22 of wheat, 51 of maize, 12 of sorghum, 13 of pearl millet, 8 of finger millet, and smaller numbers of other millets and barley. Additionally, 55 high-yielding oilseed varieties were released, covering Indian mustard, yellow sarson, groundnut, soybean, and others like linseed, safflower, sesame, sunflower, niger, and castor. A total of 69 high-yielding pulse varieties were also released, including chickpea, pigeon pea, lentil, fieldpea, mungbean, cowpea, and several others. Furthermore, 107 high-yielding commercial crop varieties (cotton, Bt cotton, jute, mesta and sugarcane) and 47 high-yielding varieties of forage and other crops (forage pearl millet, maize, sorghum, grain amaranth, winged bean, tobacco etc.) were released. In horticultural crops, a total of 189 varieties in 75 crops were released.Total breeder seed production in field crops was 1,06,397.6 q against the indent of 62,104.7 q. Overall, 4,28,046.0 q of quality seed, including foundation, certified, and truthfully labelled seeds, was produced. Additionally, 103.9 lakh planting material and 10.4 lakh tissue culture plantlets were produced, exceeding targets.

Research and innovations led to significant advancements in crop yield improvement, pest management, disease detection, and sustainable farming practices. Broad-bed furrow sowing in soybean increased yields by 20-25%, improving moisture retention and soil fertility. In jute farming, deficit irrigation optimized with AquaCrop modelling boosted fiber yields by up to 44% during dry periods. Intercropping systems, such as tobacco with blackgram in Karnataka, enhanced land efficiency and productivity, while customized fertilizers have increased tobacco yields by 15%. Environment-friendly practices, like raised bed systems and zero-tillage wheat farming, optimize energy use and irrigation, and water-efficient sugarcane clones reduce water consumption without compromising yields. Additionally, multi-layer seed coatings incorporating fungicides, insecticides, and biofertilizers have improved crop establishment, and nano-zinc oxide has boosted chickpea and urdbean yields by up to 35%. The Eco-friendly Irrigation Alert System (e-IAS) and methanotroph formulations aid water conservation and reduce methane emissions in rice fields. AI-based pheromone traps monitor cotton pink bollworm in real-time, aiding pest control through mobile apps, while intercropping maize with cowpea reduces fall armyworm infestations by 60%, promoting natural predators and minimizing pesticide use. Pest-resistant maize and cotton varieties, molecular diagnostic tools for wheat diseases, and microbe-based technologies like *Pseudomonas fluorescens* for chickpea wilt control improved pest and disease management. Nano-sulphur and Fluopyrum nematicides managed pests in jute and tobacco, while the PusaMeFly Kit offered an eco-friendly solution for fruit flies. Integrated pest management strategies and AI-based detection systems proved effective for crops like maize and mustard. In horticulture, practices like light thinning and foliar 2,4-D application in pomegranate have optimized fruit weight and yield, and high-density planting and fertigation have benefited guava. Vertical nursery expansion in apple rootstocks and organic matter recycling in *Annona* hybrid Arka Sahan have enhanced soil nutrients and productivity. Pollination management for date palms and coconut farming systems increased crop efficiency. Drip irrigation and mulching significantly boosted yields in okra and tomato, while nano-urea applications improved nitrogen-use efficiency in ginger and turmeric. Microbial treatments like Kush Bio-Pulse controlled grape diseases, and the development of a systemic suckericide for tobacco and a PCR-based diagnostic protocol for bacterial blight in pomegranate supported sustainable practices.

Livestock Improvement and Management: A newly bred synthetic Frieswal cattle breed has the potential to produce 7,000 kg of milk per lactation. The Frieswal female calf was produced through OPU-IVF-ET. Genetic improvements in Gir, Kankrej, and Sahiwal breeds increased milk yield by 53.71% and reduced age at first calving by 16.73% reduction from 2010 to 2023. Advanced genome editing led to the birth of an MSTN knockout calf with improved muscle traits and sex-predetermined embryos using CRISPR. Cloned bulls performed similarly to non-cloned ones, and a buffalo bull fertility chip was developed to identify sub-fertile bulls. Recombinant FSH and LH hormones for buffaloes were validated by LC-MS/MS, and estrus detection using saliva crystallization was explored. Murrah buffaloes achieved a 305-day lactation yield of 2,665 kg in 2023-24, a 66.35% improvement since the project's start. The Network Project on Sheep Improvement involved 146 breeders and 13,832 sheep, identifying 4,461 new animals and recording 9,856 performances. ICAR-NIANP synthesized a Kisspeptin analogue for estrus synchronization in ruminants. A mobile Artificial Insemination lab (Avi MAIL) was developed to enhance sheep breeding. The AICRP on Poultry Breeding distributed 10,40,567 chicken germplasm to 14,113 beneficiaries. A Goya crossbred pig variety was developed for coastal regions. CARI-Toxomin, a herbal toxin binder, replaces inorganic binders in poultry feed, while CARI Boost improves growth and immunity, and CARI Egg Shield extends egg shelf-life. Mitochondrial dysfunction linked to retained placenta in crossbred cattle was identified, affecting placental expulsion. Positive selection in MHC genes in indigenous dairy cattle boosts immunity. Milk exosomes were explored as drug delivery vehicles, improving mastitis treatment. Green nano-antibacterial technology combats multi-drug-resistant bacteria in poultry. An AI-based system using CNNs was developed for diagnosing parasitic infections in mithun. A novel fixator and circular ESF were developed for treating open fractures. NADRESv2 issued 17.5 million SMS alerts in Karnataka, generating over 5,600 risk predictions for livestock diseases. Sero-surveillance for One Health diseases like Leptospirosis identified 120 positive samples. An indigenous BVDV-1 vaccine provides immunity for 12 months, while a live-attenuated LSD vaccine showed high seroconversion. Diagnostic tests for FMDV, SARS-CoV-2, and PCV3 were developed with high sensitivity. Early detection kits for LSD were released. A national FMD sero-surveillance tested 49,481 samples, revealing 16.7% bovine seropositivity, with improved protection after vaccination. A negative marker trivalent FMD vaccine, developed using reverse genetics, demonstrated similar protection to the wild-type vaccine. Thermostable FMDV strains were selected for harsh climates.

Fish Improvement and Management: Success was achieved in captive breeding of golden trevally (*Gnathanodon speciosus*), a potential species for sea farming, by raising broodstock in open sea cages for 3-4 years, in a Recirculating Aquaculture System (RAS), resulting in a 14.7% survival rate. Achieved captive breeding of the dwarf chameleon fish (*Badis blosyrus*), an ornamental species from Northeast India, with spawning observed in June and fry becoming free-swimming after 6-8 days under optimal water conditions. Seed production package for peacock eel (*Macrognathus aral*) was also developed, including induced breeding with hormonal treatment, with 45% fertilization and 20% hatching rates. A multi-location farming trial of CIFA-GI Scampi® in Assam under the Pradhan Mantri Matsya Sampada Yojana showed promising results. A GnRH injectable formulation for induced breeding was developed and tested successfully in Indian major carps (IMC) and other species, enhancing spawning efficiency across diverse fish species. National Ranching Programme has successfully restored native fish species like IMC and Mahseer in the Ganga River across states. This led to doubling of fish landings in the Buxar stretch (Bihar) between 2017-18 and 2023-24. Under the programme also released hilsa fish seeds upstream of the Farakka barrage and 102 awareness programmes were conducted to promote sustainable fishing practices, reaching over 7,500 stakeholdrs. Developed CIFE-GlowX, a feed enhancing the growth and coloration of ornamental fish, and Cadalmin™ Silvergrow, a feed for silver pompano. Furthermore, CIFE-SPOT, a rapid CRISPR-based diagnostic tool for detecting White Spot Syndrome Virus (WSSV) in shrimp was developed, aiding proactive disease management in aquaculture.

Management of Genetic Resources: ICAR made significant progress in agrobiodiversity management through its five national bureaux. For plant genetic resources, through 20 germplasm exploration missions, 1,000 accessions were collected, and the National Genebank received 3,198 new seed accessions, bringing the total to 4,70,513. The *in-vitro* Genebank had an addition of 39 accessions, and 225 accessions were added to the Cryogenebank, taking the total to 13,047. Stress resistance characterization was completed for 20,192 accessions, with core sets developed for sesame, barley, and barnyard millet. Plant quarantine of 1,34,067 imported samples was carried out, and DNA fingerprinting and GMO testing were performed on several varietal samples. In horticulture, notable additions included 92 *in-vitro* potato accessions and several *Piper* species from North-eastern India. Seven new indigenous animal breeds were registered, and genomic chips were developed for indigenous cattle and buffaloes. For *ex situ* conservation, semen and somatic cells from 29 at-risk indigenous breeds were cryopreserved. New fish and shellfish species were discovered, genetic characterization of aquaculture species conducted, and genome of Indian major carp was sequenced. Two online databases for crustaceans and Hilsa shad were developed. The Microbial Culture Collection was expanded with 604 new strains, bringing the total to 8,500 accessions. Additionally, DNA fingerprinting of biopesticides and insect species has improved pest management and biodiversity understanding.

Soil and Water Productivity: Slope and crop cover maps of India are very important to estimate soil erosion by considering climatic conditions, soil properties, topography, crop and soil management practices. C-factor map of India, one of the most important parameters, was made using land use and land cover map of India. Slope map of India was prepared using ASTER DEM (30-m resolution) for estimating the P-factor map of India. Conventional soil testing is time-consuming, labour-intensive, and expensive. Hence, efforts are being made across the globe to develop rapid and less expensive methods of assessing soil health parameters. One promising approach is spectroscopic soil analysis, an emerging technology that enables the rapid, non-destructive, and cost-efficient characterization of soil health indicators. Among the different properties evaluated, soil organic carbon, pH, sand, silt and clay content, soil water retention capacity at field capacity and permanent wilting point were predicted with reasonably good accuracy. This technique has the potential for its application in precision agriculture, monitoring soil quality in landscapes, and digital soil mapping.

Mechanization and Energy Management: A variety of sensor-based, robotic and mechanical tools were developed to enhance agricultural operations at various stages. These include an image-based nitrogen applicator that adjusts fertilizer based on crop stress, and a multi-purpose unmanned vehicle for planting and weeding on small farms. Other innovations include a sensor-based fertilizer applicator for grape vineyards, a microcontroller-based poultry feed dispenser, and a radio frequency-controlled pesticide applicator. Additionally, a device for real-time detection of Groundnut Bud Necrosis Virus (Gbnv) using machine learning has been created for rapid disease severity estimation. A robotic metering system for vegetable transplanting and a Variable Rate Technology (VRT) robot for precise fertilizer application have also been designed, improving efficiency and reducing labour costs in farming. In field operations, innovations like the tractor-drawn eight-row onion transplanter, mechatronic planters for intercropping, and tractor-operated leaf detrashers for sugarcane have been introduced to increase efficiency.

Post-Harvest Management and Value Addition: Innovative technologies were developed to enhance food security, sustainability, and workplace safety, with a focus on reducing environmental impact. The Visible Light Insect Trap used energy-efficient LEDs to attract and trap insect pests that damage stored grains, achieving 65-93% efficiency without harming the environment. The Table-top Vacuum Fryer fried food at lower temperatures, preserving nutrients and colour while reducing harmful compounds like acrylamide, making it ideal for small-scale food production. Makhana Puffs, created from by-products of makhana and other grains, offers a protein-rich snack for children. Sustainability was further supported by Mycelium-Based Packaging, which converted agricultural residues into biodegradable packaging, and the Multi-Crop Processing Machine, which helped farmers process crops efficiently and improve productivity. Industrial Cut-Resistant Gloves, made from cotton and UHMWPE fibers, provided durable protection in industries such as construction. Sustainable Leather Products, made from agricultural by-products, offered an eco-friendly alternative to traditional leather. In food processing, treatments like ozone and ascorbic acid extended the shelf-life of tender jackfruit, and an edible coating for tomatoes using carboxymethyl cellulose CMC and lemongrass oil extended their shelf-life by 15 days. The HyperAfla instrument detected aflatoxin in maize with 81% accuracy. Other innovations included the power-operated jackfruit cutting machine, the tender jackfruit peeling machine, and the baby corn grader, all of which improved processing efficiency. Sustainability innovations included the solar-powered bhatta for button lac production, reducing wood dependence, and the paddy straw-based insulating box for vegetable storage. Biodegradable films made from PLA and corn starch addressed plastic pollution, with an annual output of 240 tonnes.

Climate Resilient Agriculture: Climate change has negatively impacted crop yields, such as reducing wheat productivity in India. For crops like rice and sorghum, regional variations in productivity are expected due to climate factors, with some states facing significant yield losses. Studies on greenhouse gas emissions from agricultural practices highlight the role of residue management and soil type in CO_2, N_2O, and CH_4 emissions. For example, Vertisol and Inceptisol soils showed varying N_2O flux responses, stressing the need for region-specific approaches to residue management. Technological advancements, including digital tools for soil health monitoring and crop modelling under changing climates, offer key insights for adaptive strategies. Innovations like bioethanol production from jute and kenaf contribute to a low-carbon economy. Developing climate-resilient crop varieties and innovative farming practices is vital for addressing climate change challenges and improving food security. New crop varieties and hybrids, such as high-yielding, drought-resistant rice varieties Swarna Purvi Dhan 1, 2, and Swarna Shusk Dhan, are suitable for water-limited areas. Pomegranate hybrids, such as Jalore with Bhagwa and Mridula, showed improved fruit size, colour, and yield. New moth bean varieties, CAZRI Moth 4 and 5, significantly outperformed existing ones, while mustard strains for organic farming, like MM16A241, showed higher seed yields.

Agricultural Education: ICAR restructured the undergraduate curriculum in 13 agricultural disciplines through the Sixth Dean's Committee Report, to align with the National Education Policy, 2020. It includes a flexible curriculum, with multiple entry and exit points and integration of the Academic Bank of Credits (ABC), and enhances employability through skill training and internships programmes. ICAR continued focus on quality education, by facilitating accreditation to 37 agricultural universities (AUs) through its National

Agricultural Education Accreditation Board. Two Vice-Chancellors' Conferences were held to improve institutional effectiveness, and virtual meetings with 76 AUs discussed artificial intelligence (AI) in agriculture and the 'Viksit Bharat' vision. ICAR introduced a new portal and mobile app for the Student READY programme to connect students with farmers for rural development experience. ICAR also held 89 training programmes for 2,047 faculty members and over 80 capacity-building programmes for professionals across agriculture. The National Agricultural Higher Education Project (NAHEP), co-funded by the Government of India and World Bank, concluded in September 2024. This seven year project has significantly contributed in transforming agricultural education in AUs by updating curricula, adopting innovative teaching methods, and increasing student diversity, boosting interest in agricultural courses.

Social Sciences: Investment in India's agricultural R&D gives a high return of ₹13.85 from research and ₹7.40 from extension services per rupee invested. Investment in animal science research is more productive than crop research, underscoring the need for balanced funding, especially in livestock, fisheries, and natural resources. Government schemes like PM-KUSUM and PDMC aim to address groundwater and energy issues but face varying adoption rates by state. Integrating technologies could enhance water and energy efficiency, increase crop yields, and cut CO_2 emissions. Solutions include rationalizing subsidies, promoting water-saving technologies, revitalizing irrigation, and encouraging crop diversification. Vegetable price volatility is driven by seasonality and inefficient supply chains. Climate-resilient varieties, cold storage, and better transportation could stabilize prices. Agriculture is highly vulnerable to climate risks, particularly in eastern Uttar Pradesh. A vulnerability index helps target adaptation strategies. Advanced statistical methods and experimental designs improve research efficiency, with tools like the Semi-Latin Rectangles web application enhancing trial design.

Basic and Strategic Research: Under NASF, 28 new projects were approved, which focused on advanced science in areas like crop health, nano-micro matrices, genome sequencing, diagnostics, robotics, and AI-based systems for agriculture. Around 98.9% of these projects are multi-institutional. In all, 666 pre-proposals were received for Call XI in six strategic areas. Ongoing projects resulted in innovations in crop breeding, sensor technologies, and farming systems to improve productivity and sustainability. Genome editing, like CRISPR-Cas9, was used to develop rice mutants with improved drought and salt tolerance. In pest management, sensors were created to monitor crop health by detecting VOCs in infested crops. Advances in crop breeding revealed key SNPs linked to blast resistance in pearl millet and identified markers for traits in finger millet and maize. Metabolomics enabled non-invasive early disease detection. Integrated farming systems like hydroponics and aquaponics optimized resource use. Smart farming technologies, including AI-based decision support, solar-powered machinery, and robotic vehicles, are advancing precision agriculture.

Information and Communication Technology and Digital Resources: Platforms like e-HRMS 2.0 streamlined HR services for 14,626 employees, and SPARROW linked performance appraisals to research. Aadhaar-based face authentication tracked attendance, and e-Office enhanced workflow at ICAR institutes. The DARPAN Dashboard updated project data, while Kisan Sarathi connected 250 lakh farmers to experts. Initiatives like Krishikosh and Kisan Mobile Advisory Service provided essential information to farmers. ICAR's ICT innovations in precision agriculture used remote sensing, IoT, drones, and AI for sustainability. AI-driven systems optimized pest control, nitrogen management, and productivity with tools for grading jute, sorting mangoes, and robotic apple harvesting. Mobile apps like IkshuKedar for irrigation and CROP SURAKSHA for pest management supported farmers, while AI-DISC and AI-DISA were used for crop and livestock diseases. ICAR has also developed tools for crop improvement, such as Trait Specific Germplasm, Pulse Gene Bank, and machine learning systems like ASPTF and DBPMod.

Technology Assessment, Demonstration and Capacity Development: KVKs assessed over 6,000 technological options in crop management and livestock, including 1,758 crop varieties and 5,719 livestock trials. Cluster Frontline Demonstrations (CFLDs) on pulses and oilseeds showed significant yield increases, with pulses up by 34.36% and oilseeds by 29.40%. Other crop demonstrations also led to substantial yield gains, like a 45.63% rise in greengram and 40.64% in linseed. KVKs conducted 9,089 mechanization demos, 17,830 in livestock and fisheries, and 17,761 enterprise demos, focusing on women's empowerment. Over 20 lakh individuals attended 65,235 training programmes, with 49,534 courses for farmers and farm women, including 36.17% from SC/ST groups. Rural youth participated in skill development courses, and 9.33 lakh extension activities reached 395 lakh participants. Special programmes like ARYA trained 16,952 rural youth, leading to 3,398 entrepreneurial units. The NICRA project reached 49,278 farmers with climate-resilient agriculture demos, and the NARI programme set up 13,614 nutri-gardens. Other initiatives included 56,000 farmers in crop residue management, 4,416 Integrated Farming System demonstrations, and the formation of 3,093 FPOs. ICAR also launched the Agri-drone Project, conducting 15,000 drone demos across 31 states.

Research for Tribal and Hill Regions: A total of 14.83 tonnes of breeder seeds from 43 varieties of 15 crops were produced, alongside 1.21 tonnes of nucleus seed and 24.15 tonnes of Truthfully Labelled (TL) seeds. Eleven new crop varieties, including rice, maize, amaranth, and millet, were released for tribal and hilly regions, offering improved yields and disease resistance. Notable efforts included the establishment of 16 polyhouses in Chamoli district to promote protected cultivation, along with training on water management. In addition, 140 q of wheat seed and 3,200 temperate fruit plants were distributed to 105 tribal farmers. In the NEH region, 2,032 kg of seeds from 29 varieties of 14 crops were distributed across eight states, with new varieties for demonstration purposes. A participatory seed production programme for finger millet in Arunachal Pradesh involved six farmers, while millet threshers were demonstrated and distributed in Tawang. KVK Sepahijala organized a VL Solar Dryer demonstration, benefiting women farmers in Self Help Groups (SHGs). In Nagaland, four Integrated Farming System models improved profitability, soil health, and sustainability. Three animal breeds from Andaman and Nicobar Islands were recognized for local conditions, and in Minicoy, Lakshadweep, the first Fish Aggregating Device (FAD) was deployed to boost tuna fishing productivity. Under the TSP, outreach efforts reached 193 districts and trained over 17.9 lakh farmers. These included demonstrations that increased wheat and chickpea yields by 34%. Solar-powered irrigation systems in Odisha expanded irrigated areas, boosting farmers' incomes and reducing CO_2 emissions. Crop diversification in West Bengal's Chhotanagpur plateau improved yields by 30-45%, benefiting 100 tribal farmers. In Uttarakhand, the Farmers Participatory Seed Production programme helped 54 tribal farmers produce 200 q of certified wheat seed, increasing income. Similarly, in Vizianagaram, automated millet and oil processing units empowered 6,200 tribal women, enhancing local nutrition and entrepreneurship. These initiatives improved productivity, sustainability, and livelihoods for rural and tribal communities across India. The PRAYAS programme reached over 11,261 farmers, addressing quality planting material and livelihood opportunities.

Organization and Management: ICAR provided financial support to 44 societies for publishing scientific journals and facilitated 59 national and international conferences. Sixty Umbrella MoUs were signed with universities to bolster collaborative research. Under the Swachh Bharat Mission, projects such as agricultural waste management, fish waste utilization, and sewage water treatment were implemented, with ₹350 lakhs spent in 2023-24 and ₹400 lakhs earmarked for 2024-25. Campaigns like Swachhta Hi Sewa and Special Campaign 4.0 focused on file management, freeing 97,579 sq. ft. of space and generating ₹8.28 lakh in revenue. ICAR's 96th Foundation Day was marked by technology launches, exhibitions, and awards.

Finance: The Revised Estimates in respect of DARE/ICAR for 2023-24 was ₹ 9,876.60 crores. An internal resource of ₹ 499.72 crores (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2023-24. The total allocation Budget Estimates for 2024-25 is ₹ 9,941.09 crores.

Intellectual Property and Technology Management: A total of 143 new patent applications were filed across various domains of agricultural sciences at the Indian Patent Office (IPO). As a result, the cumulative number of patent applications filed by ICAR has now reached 1,706. The IPO granted 125 patents in areas such as Chemicals, Biotechnology, Food, Agricultural Engineering, Agrochemicals, Microbiology, Biochemistry, and Traditional Knowledge, bringing ICAR's total number of granted patents to 678. To safeguard plant varieties, a total of 83 applications (75 for existing varieties and 8 for new ones) were submitted to the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA) across 28 crop species from 15 ICAR research institutes. During this period, registration certificates were granted for 19 previously filed varieties. As a result, the cumulative total of plant variety protection applications reached 1,562. A total of 307 copyright applications were filed by various ICAR institutes. A total of 111 trademark applications were submitted by 37 ICAR institutes for various products and processes across 25 classes of goods and services.

Training and Capacity Building: As part of the Government of India's Mission Karmayogi initiative, 294 employees from DARE and ICAR were enrolled in the i-GOT Karmayogi platform to enhance their skills across various domains and contribute to the development of a skilled and professional workforce. The Capacity Building Unit (CBU) of DARE/ICAR implemented the Annual Capacity Building Plan (ACBP) for 2023-24, coordinating training for 2,347 employees. This included 1,267 scientists, 485 technical staff, 504 administrative/finance staff, and 91 skilled support staff (SSS). Compared to 2013-14, there was a notable increase in training, with a 31.1% rise for technical staff and a 127.5% increase for SSS. Highest number of employees trained were under Crop Science Division (595) followed by the NRM Division (425). Additionally, 271 ICAR scientists received specialized training in pedagogical skills, and 245 employees were nominated for external training programmes by other organizations. A total of 354 training programmes were organized by ICAR across categories. Overall, 16.8% of employees participated in training programmes, reflecting a 4.1% improvement in capacity building compared to 2013-14.

Partnerships and Linkages: The International Relations Division (IRD) facilitated processing of 29 MoUs for bilateral cooperation across 26 countries. Notable partnerships include those with Western Sydney University, WorldFish, ICRISAT, and the World Vegetable Center. ICAR also collaborated extensively with the Consultative Group on International Agricultural Research (CGIAR), regularly reviewing progress on joint research efforts. Multilateral cooperation was achieved through participation in global forums like G-20, ASEAN, BRICS, and QUAD. Furthermore, ICAR launched the ASEAN-India Fellowship for agricultural education and the AI-ENGAGE initiative under QUAD, which focuses on precision agriculture using AI and robotics. A total of 125 foreign delegations visited ICAR headquarters and research institutes, promoting collaboration and showcasing India's agricultural advancements.

Gender Budgeting: Gender budgeting aims to address disparities in sectors like health, education, employment, and agriculture by integrating gender considerations into budget planning. ICAR's Gender Budget Cell leads the efforts to tackle gender imbalances in agriculture, promoting policy changes and resource allocation. ICAR-CIWA worked with KVKs and AUs on gender-focused research, technology, and initiatives such as reducing women's physical labour through innovations like pedal-operated coconut dehuskers. They also trained women in drone technology and ran programmes like Nutri-Smart Villages to improve food security. ICAR has developed adaptive strategies for climate change impacts, such as resilient crops and water-saving practices. Despite significant contributions in dairy and horticulture, women are often excluded from decision-making. Entrepreneurship models like the 2S2M and GCAM empower rural women, improving their income and nutrition.

Promotion of Hindi as Official Language: ICAR ensured compliance with the Official Language Act, 1963, by promoting Hindi use in official work through various initiatives. These included organizing programmes in Hindi and regional languages for farmers and the public, publishing materials on agricultural sciences in these languages, and releasing the Hindi magazine *Kheti* and the publication *Rajbhasha Aalok*. ICAR held regular meetings of its Official Language Implementation Committees, submitted progress reports, and participated in Town Official Language Implementation Committee (TOLIC) meetings. The organization also conducted Hindi workshops, organized Hindi Pakhwara events, and awarded employees excelling in Hindi usage. Inspections and bilingual preparation of parliamentary documents ensured compliance with the language policy.

Publications, Social Media and Public Relations: The ICAR-Directorate of Knowledge Management in Agriculture (DKMA) published 12 periodicals, including three prominent journals that had 532 articles across these journals. To improve research accessibility, ICAR's e-publications platform hosted over 41,000 articles and ensured publication integrity with tools like DOIs and plagiarism checks. ICAR's website and social media platforms garnered significant engagement, with a major highlight being the '100 Days of ICAR Achievements' campaign. Additional publicity efforts included press conferences, press releases, and exhibitions to promote agricultural innovations.

I would like to express our sincere gratitude to the Hon'ble Union Minister of Agriculture & Farmers Welfare and President of the ICAR Society; Union Minister of Fisheries, Animal Husbandry & Dairying and Senior Vice-President of the ICAR Society; Union Ministers of State for Agriculture & Farmers Welfare and Vice-President of the ICAR Society; and the members of the Governing Body of ICAR Society for their valuable guidance, support, and encouragement in all the efforts of ICAR. We thank to the various stakeholders, particularly the allied Ministries and Departments of the Government of India, State Agricultural Universities, National and International Organizations, Private Sectors, Industries, and Farmers, for their collaboration and support in shaping the Council's research, education and extension programmes. ICAR initiatives, from developing high-yield crop varieties to promoting sustainable practices and digital solutions, have strengthened food security in India. Looking ahead, ICAR's role is crucial in preparing Indian agriculture for the future, emphasizing sustainability, resilience, and farmers' profitability. Through research, training, and partnerships, ICAR is laying the foundation for a robust agricultural ecosystem that will support India's growing population and contribute to global food security efforts. By anticipating future challenges and proactively developing technologies, ICAR remains committed to building skilled manpower and collaborating with stakeholders to address the evolving needs of Indian agriculture. I sincerely hope that the *ICAR Annual Report 2024-25* will be valuable to policymakers, planners, development agencies, researchers, farmers, and students in raising awareness of the significant contributions made by the ICAR and enhancing productivity, profitability, climate resilience and sustainability of Indian agriculture.

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2.
Crop Improvement

Crop and horticulture-based ICAR institutes overseen by Crop Science and Horticulture Science Divisions of ICAR, respectively, made significant advancements in seed production and research to enhance agricultural productivity and sustainability. In field crops, 524 varieties/hybrids were released, including 34 biofortified varieties and 79 varieties resistant to abiotic stresses like drought, salinity, and low temperatures. Precision breeding through marker-assisted selection was used for developing 10 trait-specific varieties. Breeder seed production in 2023-24 reached 106,398 q, surpassing the target, while overall seed production amounted to 428,046 q. Additionally, 103.9 lakh planting materials and 10.4 lakh tissue cultures were produced. Biotechnological innovations targeted pest management, including RNAi-mediated silencing of genes in pests like the PBW, resulting in significant mortality rates. A rapid, isothermal detection assay for the cassava mealybug was developed for early pest detection. In crop improvement, novel genes for disease resistance were identified in rice, including genes like OsvWA36 and OsChib1, which offer resistance to blast and sheath blight diseases, respectively. A study on heat tolerance in peart millet revealed over 13,000 differentially expressed genes, promising for heat-resistant variety development. The application of genome editing tools has also progressed, utilizing the smaller Transposon-associated TnpB for efficient genome editing in rice and Arabidopsis. A genome-wide association study (GWAS) in finger millet identified markers associated with seed longevity traits, important for improving seedling vigour under climate change. Cajanus scarabaeoides, a wild relative of pigeonpea, was sequenced, offering valuable traits for breeding. Furthermore, an in vitro regeneration system for mungbean was developed, enabling successful plantlet production. CRISPR/Cas-based genome editing is being applied to reduce lignin content in tossa jute, improving fibre quality for industrial applications like textiles and biofuels. In horticultural crops, a total of 189 varieties in 75 crops were identified by the Central Sub-Committee on Crop Standard, Release and Notification of Varieties of Horticultural Crops. Using biotechnology across various crops, focus on improving traits like resistance, yield, and quality through techniques like genome editing, marker-assisted breeding, and tissue culture was carried out. In grapes, successful embryo rescue protocols led to the development of hybrid progeny with improved characteristics, while a genome-wide association study (GWAS) identified significant SNP markers linked to key traits like berry and bunch size. In apples, SSR markers were used to identify marker-trait associations, particularly for fruit length. Pomegranate research led to the creation of 245 InDel markers associated with growth and development. For coconut, tissue culture methods were optimized for better callus induction and shoot regeneration, while in date palms, an effective micropropagation protocol was established. Oil palm research developed a CAPS marker for differentiating fruit types, facilitating earlier selection of high-yielding sprouts. Additionally, targeted genome editing and GWAS studies in potatoes advanced efforts to improve disease resistance and haploid induction for crop breeding.

FIELD CROPS

Varieties released and notified

Since 1969, a total of 6,870 improved field crop varieties have been developed which include 3,373 of cereals, 1,099 of oilseeds, 1,223 of pulses, 281 of forage crops, 661 of fibre crops, 172 of sugarcane and 61 of potential crops. During the reporting period, a total of 524 varieties/hybrids were notified and released for commercial cultivation, which include 34 biofortified varieties and 79 varieties to combat the various abiotic stresses like drought, water scarcity, flood, waterlogging, salinity, sodicity, low temperature etc. Precision breeding tool, i.e. marker-assisted selection was used in the breeding of 10 trait-specific varieties.

Cereals: A total of 246 high-yielding varieties and hybrids of cereals have been released for cultivation across various agro-ecologies of the country. These include 126 varieties of rice, 51 of maize, 22 of wheat, 13 of pearl millet, 12 of sorghum, 8 of finger millet, 4 of foxtail millet, 2 each of little millet, proso millet, kodo millet, and barnyard millet, and 1 each of barley and brown top millet. The details are listed below.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Salient features
Rice		
CR Dhan 211 (IET 29411)	Odisha, Bihar, Jharkhand, Maharashtra, Gujarat and Chhattisgarh	Suitable for aerobic condition, average grain yield 45.42 q/ha, maturity 114-118 days. Moderately resistant to neck blast, leaf blast, brown spot, sheath rot, grain discolouration, stem borer (dead heart and white ear head), leaf folder and gundhi bug insect pests.
CR Dhan 212 (IET 29424)	Odisha, Bihar and Jharkhand	Suitable for aerobic condition, average grain yield 44.51 q/ha, maturity 110–113 days. Moderately resistant to neck blast, leaf blast, brown spot, sheath rot, rice tungro disease (RTD), grain discolouration, stem borer (dead heart and white ear head), leaf folder, whorl maggot and gundhi bug insect pests.
CR Dhan 214 (IET 29436) (CRR 821-21-2-1-3)	Odisha and Bihar	Suitable for aerobic conditions, yield 42.55 q/ha, maturity 110–115 days, moderately resistant to leaf blast, sheath rot and RTD.
CR Dhan 322 (CR3969-17-2-2-1-1-1-1)	Chhattisgarh and Maharashtra	Suitable for irrigated late duration ecology condition and for late sown condition, average grain yield 54.07 q/ha, maturity 135-145 days. Moderately resistant to grain discolouration. Moderately susceptible to leaf blast and neck blast under disease screening nursery, stem borer (dead heart), leaf folder. Resistant to lodging and fertilizer responsive.
CR Dhan 329 (IET29236) (CR 3580 - 3-1-1-1-1-1-2)	Gujarat, Maharashtra, Odisha and Bihar	Suitable for irrigated mid early duration ecology, average grain yield 55.23 q/ha, maturity 125-130 days. Moderately resistant to neck blast, brown spot, sheath rot diseases, false smut, brown plant hopper (BPH) and other plant hopper and stem borer (dead heart). Highly tolerant to leaf folder, whorl maggot and rice thrips. Non-lodging, intermediate grain shattering, fertilizer responsive.
CR Dhan 331 (IET 28508)	Maharashtra and Chhattisgarh	Suitable for irrigated late duration ecology, average grain yield 52.15 q/ha, maturity 140 days, tolerant to neck blast. Moderately tolerant to bacterial blight, leaf blast and sheath rot diseases. Resistant to leaf folder and moderately resistant to stem borer.
CR Dhan 804 (IET 28032) (CRR 751-1-7-B-B)	Jharkhand, Uttar Pradesh, Tamil Nadu, Madhya Pradesh, Chhattisgarh, Andhra Pradesh and Telangana	Suitable for drought-prone rainfed/irrigated shallow low lands conditions, average grain yield 48.82 q/ha, maturity 115–120 days. Developed through marker assisted selection (MAS), a near isogenic line (NIL) from IR64 *Sub1* with introgression of *qDTY2.2* for yield under drought stress. Resistant to blast, and moderately resistant to brown spot, bacterial leaf blight (BLB), sheath rot, sheath blight and RTD.
CR Dhan 807 (CR 4333-35-2-2-1) (IET 30438)	Jharkhand, Odisha, Andhra Pradesh, Tamil Nadu, Chhattisgarh and Gujarat	Suitable for early direct seeded rainfed upland ecology with herbicide tolerance, average grain yield 44.02 q/ha, maturity 105-110 days. Developed through MAS by herbicide tolerant Robin mutant in the background of Sahabhagidhan. Moderately resistant to brown spot and blast disease, tolerant to stem borer.
CR Dhan 808 (IET 28834) (CRR 809-11-1-9-B)	Bihar and Jharkhand	Suitable for direct seeded drought-prone rainfed areas, average grain yield ROS-16.8 q/ha and under drought-22.14 q/ha, maturity 90-95 days. Developed through MAS, a NIL in the background of Anjali with introgression of *qDTY12.1* and *qDTY3.1* for yield under drought stress. Moderately resistant to blast, brown spot, gall midge, stem borer, leaf folder and white backed plant hopper.
Uttar Ganga (PUR-B-190) (IET 28840)	West Bengal, Odisha and Uttar Pradesh	Suitable for Boro irrigated ecology, average grain yield 61.44 q/ha, maturity 140-145 days. Resistant to leaf blast, neck blast, brown spot, sheath blight, sheath rot, BLB and RTD. Tolerant to major pests like stem borer, leaf folder, gall midge and whorl maggot. Resistance to lodging and shattering.
Kaveri Rice Hybrid-7299 (IET 28954)	Haryana, Punjab, Rajasthan, Uttarakhand, Bihar, Uttar Pradesh, Odisha and West Bengal	Suitable for irrigated both high and low fertility soil average grain yield 61.11 q/ha, maturity 120 days. Moderately resistance to leaf blast, neck blast, brown spot and glume discolouration diseases.
S7004 (IET 29001)	Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, Andhra Pradesh and Tamil Nadu	Suitable for irrigated medium ecology, average grain yield 61.97 q/ha, maturity 135 days. Moderately tolerant to leaf blast, neck blast and brown spot diseases.
Spoorthi (GNV 1906) (IET 28694)	Tamil Nadu, Telangana, Andhra Pradesh and Karnataka	Suitable for irrigated transplanting ecology, average grain yield 53.26 q/ha, maturity 125-130 days, biofortified variety with high zinc content of 20.05 ppm.
NK 5231 (IET 28849)	Uttar Pradesh, West Bengal and Assam	Suitable for irrigated, medium ecology (boro season), yield 62.82 q/ha, maturity 140-145 days. Resistant to leaf blast, tolerance to BLB, neck blast.
DR 8611 (IET 29017)	Maharashtra, Gujarat, Chhattisgarh and Madhya Pradesh	Suitable for irrigated ecosystems, average grain yield 50.25 q/ha, maturity 127-132 days. Tolerant against neck blast, bacterial leaf blight, sheath blight, false smut, brown plant hopper, white backed plant hopper, stem borer, leaf folder and plant hopper.

Variety	Area of adoption	Salient features
DRR Dhan 70 (IET 29415)	Odisha and Bihar	Suitable for aerobic condition, average grain yield 45.80 q/ha, maturity 126 days. Moderately resistant to leaf blast, brown spot, sheath rot, rice tungro disease and grain discolouration. Moderately tolerant to brown plant hopper, plant hoppers, stem borer, gall midge and leaf folder.
DRR Dhan 71 (IET 29421)	Odisha, Gujarat and Tamil Nadu	Suitable for aerobic condition, average grain yield 48.70 q/ha, maturity 125 days. Moderately resistant to leaf blast, neck blast, brown spot, sheath rot, RTD, sheath blight and grain discolouration. Moderately tolerant to plant hoppers, stem borer, gall midge and leaf folder.
DRR Dhan 72 (IET 28821)	Karnataka and Telangana	Suitable for irrigated areas with low soil phosphorous, average grain yield 50.41 q/ha, maturity 130-135 days, nutrient use efficient variety. Moderately resistant to neck blast, leaf blast, brown spot, brown plant hoppers and leaf folder. Resistant to whorl maggots.
DRRH-5 (IET 27847)	West Bengal, Gujarat, Goa and Andhra Pradesh	First hybrid developed for coastal salinity condition, average grain yield 34.36 q/ha, maturity 124 days. Moderately resistant to leaf blast, neck blast, sheath rot and plant hoppers.
INH 211120 (IET 28950) (HRI-207)	Punjab, Haryana, Western Uttar Pradesh, Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam, Tripura, Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, Telangana, Andhra Pradesh, Tamil Nadu and Karnataka	Suitable for irrigated lowland, average grain yield 60.35 q/ha, maturity 115 days, resistant to bacterial leaf blight and BPH.
AZ 8455 DT (IET 28997) (HRI-204)	Punjab, Haryana, Western Uttar Pradesh, Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Madhya Pradesh and Chhattisgarh	Suitable for irrigated lowland, average grain yield 63.33 q/ha, maturity 130-135 days, resistant to BLB and BPH.
JKRH 2728 (IET 28848)	Odisha, Uttar Pradesh, Assam and Tripura	Suitable for irrigated transplanted/rainfed condition, average grain yield 66.56 q/ha, maturity 148 days. Tolerant to BLB, leaf blast, neck blast, sheath blight and brown spot diseases. Resistant reaction to BPH and white backed plant hopper (WBPH).
Bheem-115 (IET 28964) (VNR 227)	Uttar Pradesh, Bihar, Jharkhand and Odisha	Suitable for irrigated and rainfed ecologies, average grain yield 59.50 q/ha, maturity 115 days. Moderately resistant to leaf blast, neck blast, brown spot and glume discolouration.
MTU Rice 1275 (IET 27908)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Puducherry	Suitable for irrigated conditions, average grain yield 67.86 q/ha, maturity 140 days. Moderately resistant to leaf blast, neck blast, BLB and brown spot diseases.
Malaviya Manila Sinchit Dhan-1 (IET 26898)	Odisha and Bihar	Suitable for irrigated transplanted ecology, average grain yield 53.99 q/ha, maturity 118 days. Moderately resistant to leaf blast, brown spot, false smut diseases, stem borer, leaf folder, caseworm and whorl maggot insect pests.
RRX 3350 RRX - 809 (IET 28982)	Punjab and Haryana	Suitable for irrigated ecology, average grain yield 64.00 q/ha, maturity 123-128 days. Moderately resistant to leaf blast, neck blast, sheath blight diseases, plant hoppers, leaf folder and whorl maggot.
RRX – 3200 RRX – 848 (IET 28960)	Haryana, Punjab, Uttar Pradesh, Bihar, Odisha, West Bengal, Jharkhand, Chhattisgarh, Madhya Pradesh, Gujarat and Maharashtra	Suitable for irrigated ecology, average grain yield 59.91 q/ha, maturity 115-120 days. Moderately resistant to leaf blast, neck blast, plant hoppers and tungro virus. Tolerant to stem borer.
28P68 (IET 29004) (PHI-20107)	Uttar Pradesh, Bihar, Jharkhand, Odisha and West Bengal	Suitable for irrigated ecology, average grain yield 69.28 q/ha, maturity 130 days. Moderately resistant to leaf blast, neck blast and brown spot diseases. Tolerant to leaf folder pest.
Sava 7501 (SHX-468) (IET 28128)	Western Uttar Pradesh, Jammu and Kashmir, and Punjab	Suitable for irrigated, high fertility ecology, yield 65.33 q/ha, maturity 122-126 days. Moderately resistant to leaf blast, neck blast and brown spot diseases.
Sava 7301 (SHX 015) (IET 27328)	Uttar Pradesh, Jharkhand, West Bengal, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Kerala	Suitable for irrigated, high fertility ecology, average grain yield 65.35 q/ha, maturity 115-118 days. Moderately resistant to leaf blast, neck blast, brown spot, sheath blight and BLB.
BPT Rice 3050 (IET 29256)	Gujarat and Maharashtra	Suitable for irrigated ecology, average grain yield 54.30 q/ha, maturity 135 days. Resistant to leaf blast, neck blast and brown spot diseases. Moderately resistant to BPH, WBPH insect pests.
KKL (R) 3 (IET 27807)	Haryana, Puducherry and Tamil Nadu	Suitable for salt affected areas (alkaline ecology), average grain yield 35.30 q/ha, maturity 110-115 days. Tolerant to gall midge. Moderately resistant to stem borer, leaf folder insect pests, neck blast and sheath rot diseases.

Variety	Area of adoption	Salient features
VL Barik Dhan (VL Dhan 89) (IET 28895)	Uttarakhand, Himachal Pradesh and Jammu and Kashmir	Suitable for irrigated hill ecology, yield 45.00 q/ha, maturity 115-120 days. Moderately resistant to leaf blast, neck blast, brown spot, sheath blight, bacterial leaf blight, brown plant hopper, white backed plant hopper, stem borer and leaf folder under controlled conditions.
Telangana Rice - 1289 (IET 29351)	Gujarat, Maharashtra and Chhattisgarh	Suitable for irrigated late ecology, average grain yield 53.78 q/ha, maturity 140 days. Moderately resistant to leaf blast, neck blast, sheath rot, Glume discolouration, BPH and WBPH. Resistant to plant hoppers.
Telangana Rice 7037 (IET 28356)	Odisha, Uttar Pradesh and West Bengal	Suitable for irrigated, early conditions, average grain yield 57.16 q/ha, maturity 115-120 days, moderately resistant to leaf blast.
Chandragiri (Ouat Kalinga Rice 9) (IET 27880)	Odisha, Bihar and West Bengal	Suitable for irrigated medium land and upland high fertility ecology, yield 58.91 q/ha, maturity 120-125 days. Moderately resistant to sheath rot, blasts diseases, BPH, leaf folder and stem borer pests.
Mahendragiri (Ouat Kalinga Rice 10) (IET 29177)	Chhattisgarh and Maharashtra	Suitable for irrigated medium land and upland under high fertility, average grain yield 57.61 q/ha, maturity 120 days. Moderately resistant to sheath rot, blasts, BPH, leaf folder and stem borer.
Him Palam Dhan 3 (IET 27472) HPR 2865	Himachal Pradesh and Uttarakhand	Suitable for transplanted rice production under hills of Himachal Pradesh and Uttarakhand, average grain yield 38.14 q/ha, maturity 130 days. Moderately resistant to leaf and neck blast, BPH, WBPH, leaf folder and stem borer.
Him Palam Dhan 4 (IET 28882) HPR 3201	Himachal Pradesh and Uttarakhand	Suitable for irrigated/early hills condition, average grain yield 44.29 q/ha, maturity 120-130 days. Moderately resistant to leaf and neck blast (under artificial inoculated conditions), and leaf folder and stem borer.
TRC 2020-14 (IET 29409)	Bihar and Odisha	Suitable both for irrigated and aerobic conditions, average grain yield 41.10 q/ha, maturity 117 days. moderately resistant to leaf blast, neck blast, BLB, sheath blight, brown spot, RTD, BPH and grain discolouration.
Indam 300-007 (IET 21734)	Assam	Suitable for irrigated condition, average grain yield 36 q/ha, maturity 128 days, tolerant to important pests and diseases.
GR-23 (Navsari Paushtik) (IET 27167)	Gujarat	Suitable for irrigated/mid-early condition, maturity 125-130 days, average grain yield 52.57 q/ha. High in zinc (20.4 ppm), iron (5.32 ppm) and protein (12.18%). moderately resistant to bacterial leaf blight, grain discolouration and leaf blast. Tolerant reaction to brown plant hopper and leaf folder. Resistant to lodging, shattering, fertilizer responsive, suitable for early or late sown conditions.
GR-24 (Navsari Parimal) (IET 29995)	Gujarat	Suitable for irrigated/mid-early condition, average grain yield 44.40 q/ha, maturity 110-115 days.
GR-25 (Mahatma) (NVSR 3169) (IET 29778)	Gujarat	Suitable for irrigated/medium condition, yield 52.06 q/ha, maturity 130-135 days.
GR-26 (Navsari Lalmoti) (NVSR-6158) [IET-28714]	Gujarat	Suitable for irrigated/mid-early condition, average grain yield 48.49 q/ha, maturity 125-130 days, high in zinc (21.68 ppm), iron (7.49 ppm) and protein content (11.91%).
MTU Rice 1271 (IET 27416)	Andhra Pradesh	Suitable for irrigated/ medium condition, average grain yield 65.00 q/ha, maturity 140 days, moderately resistant to BPH.
Amreng (AAU DPU Dhan 07) (IET 29271)	Assam	Suitable for irrigated medium condition, average grain yield 55.06 q/ha, maturity 141 days. Moderately resistant to blast and sheath blight disease.
Gujarat Aerobic Rice 201 (GAR 201 : Anand Aksha 1) (NWGR-13031) (IET-27208)	Gujarat	Suitable for aerobic condition, average grain yield 39.88 q/ha, maturity 117 days. Moderately resistant reaction against white backed plant hopper and leaf folder.
Nellore Rice 3238 (NLR 3238) (IET 24336)	Andhra Pradesh	Suitable for irrigated/medium early condition, yield 53.12 q/ha, maturity 120-125 days.
BPT Rice 2846 (IET 28737)	Andhra Pradesh	Suitable for irrigated/late condition, average grain yield 50.74 q/ha, maturity 145-150 days.
BPT Rice 2841 (IET 27434)	Andhra Pradesh	Suitable for irrigated/ medium condition, average grain yield 52.57 q/ha, maturity 130-135 days.
Rajendranagar Vari – 28361 (RNR 28361) (IET 28416)	Telangana	Suitable for irrigated/mid-early condition, average grain yield 57.15 q/ha. Maturity 130 days.
Warangal vari 1119 (WGL 1119) (IET-27868)	Telangana	Suitable for irrigated/early condition, average grain yield 51.70 q/ha, maturity 115-120 days.
Pusa JRH 56 (IET 27333)	Madhya Pradesh	Suitable for irrigated/mid-early condition, average grain yield 61.51 q/ha, maturity 128 days. Moderately resistant to bacterial blight, false smut and leaf folder. Completely free from sheath blight, blast and bunt diseases. Lower incidence of BPH, WBPH. Free from hispa.
Karjat 10 (IET – 23649)	Maharashtra	Suitable for timely sown rainfed/irrigated condition in transplanted conditions during *kharif* season, average grain yield 50-52 q/ha, maturity late (140-145 days). Moderately resistant to bacterial leaf blight, blast, stem borer.

Variety	Area of adoption	Salient features
HKR-49 (HKR 16-1-IR14L521 (IET 27866)	Odisha, Bihar, Maharashtra and Gujarat	Suitable for irrigated early transplanted conditions and fits for multiple cropping system, average grain yield 57.56 q/ha, early maturity (118 days), low grain shattering. Resistant to false smut, moderately resistant to brown spot and leaf blast.
Chhattisgarh Bhavya Dhan (IET 29523)	Jharkhand, Assam, Tripura, Chhattisgarh, Maharashtra, Gujarat, Karnataka	Suitable for both rainfed and irrigated medium duration ecology, average grain yield 55 q/ha, maturity 123-133 days. Moderately resistant to leaf blast, gall midge.
Telangana Rice-1355 (WGL 1355) (IET 29188)	Odisha, West Bengal, Bihar, Telangana and Kerala	Suitable for irrigated mid-early duration ecology, average grain yield 64 q/ha, maturity 125-130 days.
Telangana Rice-34560 (JGL 34560) (IET 29833)	Telangana and Karnataka	Suitable for irrigated medium duration ecology, average grain yield 66 q/ha, maturity 135 days. Moderately resistant to leaf blast, neck blast.
Telangana Rice–35085 (JGL 35085) (IET 29142)	Bihar and West Bengal (Zone III)	Suitable for irrigated early transplanted ecology, yield 55 q/ha, maturity 120-125 days. Moderately resistant to leaf blast, neck blast.
ICAR NEH NICRA Aerobic Dhan 2 (IET 29409)	Bihar and Haryana	Suitable for aerobic cultivation with mid early duration, average grain yield 41 q/ha, maturity 135 days. Moderately resistant to leaf blast, neck blast, sheath rot.
DRRH6 (IET 28123) IIRRH-130	Odisha, Bihar, Uttar Pradesh, Gujarat and Maharashtra	Suitable for irrigated transplanted early sown conditions, average grain yield 58.5 q/ha, early maturity (120 days). Moderately resistant to neck blast, leaf blast, bacterial leaf blight, sheath blight, false smut, brown spot, RTD. Resistant to stem borer and leaf folder.
Swarna Purvi Dhan 4 (IET 29405)	Haryana, Bihar and Jharkhand, Gujarat	Suitable for direct seeded aerobic condition in water limiting areas during *kharif*, average grain yield 42.96 q/ha, early maturity (115-120 days), resistant to shattering, neck blast. Fertilizer responsive, tolerant to multi-stages drought and major pests like stem borer (white ears head), whorl maggot, caseworm, gall midge (biotype 4M) and leaf folder. Moderately resistant to leaf blast, brown spot, sheath blight, sheath rot.
Swarna Purvi Dhan 5 (IET 29036)	Bihar, West Bengal and Jharkhand	Suitable for direct seeded aerobic condition in drought prone rainfed as well as water limiting areas during *kharif*, average grain yield under normal condition 43.69 q/ha, under moderate drought condition 29.02 q/ha, early maturity (110-115 days), contains high amount of zinc (25.5 ppm) and iron (13.1 ppm). Resistant to neck blast and stem rot. Moderately resistant to leaf blast, brown spot, and sheath rot. Tolerant to major pests like stem borer (dead heart and white ears head), gall midge, leaf folder, gall midge, rice thrip.
CR Dhan 108 (IET29052)	Odisha, Bihar	Suitable for early direct seeded rainfed condition, average grain yield 34.46 q/ha, maturity 110-114 days. Moderately resistant leaf blast, neck blast, sheath blight, plant hopper. Moderately tolerant to drought.
CR Dhan 332 (IET 28506)	Odisha, West Bengal, Assam	Suitable for irrigated mid-early condition, average grain yield 57.58 q/ha, maturity 125-130 days. Moderately resistant to brown spot, sheath rot, leaf folder, whorl maggot, thrips.
CR Dhan 337 (IET 29939)	Odisha, Bihar, Jharkhand, West Bengal	Suitable for irrigated early situation, average grain yield 59 q/ha, maturity 118-121 days. Moderately resistant to neck blast, leaf blast, BLB, sheath rot, RTD and grain discolouration. Highly tolerant to leaf folder, stem borer (dead heart) and whorl maggot.
CR Dhan 416 (IET 30201)	West Bengal, Maharashtra, Gujarat	Suitable for coastal saline areas, average grain yield 48.97 q/ha, maturity 125-130 days. Moderately resistant to brown spot, neck blast, sheath rot, rice tungro disease, glume discolouration. Resistant to brown plant hopper, grasshopper and stem borer.
CR Dhan 809 (IET 30282)	Odisha, Tripura, West Bengal, Bihar, Jharkhand and Assam	Suitable for irrigated mid-early situation, average grain yield 52.9 q/ha, maturity 125-130 days. Moderately resistant to blast, false smut and glume discolouration. Resistant to brown plant hopper.
CR Dhan 810 (IET 30409)	Odisha, West Bengal and Assam	Suitable for rainfed shallow low land, average grain yield 42.38 q/ha, maturity 150 days, submergence tolerance for 14 days at early stage, moderately resistant to brown spot disease, leaf folder and stem borer (dead heart).
CR Dhan 811 (IET 30410)	Odisha and West Bengal	Suitable for rainfed shallow lowland, average grain yield 36.6 q/ha, maturity 151 days, developed through marker assisted backcross breeding, submergence tolerance at early stage. Resistant to sheath rot, leaf folder. Moderately resistant to stem borer (dead heart).
VL Bosi Dhan (VL Dhan 90, VL 32585) (IET 28883))	Irrigated transplanted conditions of medium hills of Uttarakhand, Himachal Pradesh and Jammu and Kashmir	Suitable for irrigated, medium elevated hills during *kharif* in low fertility condition, average grain yield 49.07 q/ha, maturity 115-120 days. Moderately resistant to leaf blast, neck blast, brown spot, sheath blight, bacterial leaf blight, BPH, WBPH, stem borer and leaf folder.
NLR Rice 3684 (IET 29947)	Odisha, Bihar, Uttar Pradesh and West Bengal in Zone III; Andhra Pradesh and Karnataka in Zone VII	Suitable for irrigated transplanted conditions, average grain yield 57.16 q/ha, maturity early (120-125 days), non-lodging, low grain shattering, fertilizer responsive. Moderately tolerant to leaf blast and rice brown spot disease.

Variety	Area of adoption	Salient features
KKL (R) 4 (IET 30697) (KR 19011)	Tamil Nadu, Andhra Pradesh, Telangana and Puducherry	Suitable for submergence stress conditions, average grain yield 38 q/ha under stress situations and 56 q/ha under normal conditions, maturity mid-early (120-125 days), MAS derived NIL entry of ADT39*4/ Swarna Sub1 introgressed with QTL Sub1 for submergence tolerance, moderately resistant to leaf blast.
CSR 101 (IET 30827)	Uttar Pradesh, Haryana, Tamil Nadu, Karnataka	Suitable for irrigated alkaline/saline stress areas, average grain yield of 35.15 q/ha (alkaline stress); 39.33 q/ha (saline stress) and 55.88 q/ha (normal condition), maturity 125-130 days, MAS derived NIL of Pusa 44 (possessing two genes for bacterial blight resistance xa13 and Xa21 and *saltol* QTL for salt tolerance), resistant to salinity tolerance and bacterial blight.
CSR 104 (IET 29354)	Alkaline zones of Uttar Pradesh and Haryana	Suitable for irrigated transplanted rice condition in alkaline and inland saline ecosystem, average grain yield 39.03 q/ha (alkaline stress), maturity 110-115 days. Moderately resistant to leaf blast, neck blast, brown spot, RTD, glume discolouration, stem borer, plant hopper, BPH, WBPH.
CSR 105 (IET 30004)	Aerobic or DSR condition of Zone II and VI of Haryana and Gujarat	Suitable for direct seeded aerobic condition, average grain yield 47.92 q/ha, maturity 110-120 days, slightly drought tolerant. Moderately resistant to leaf blast, neck blast, brown spot, stem borer, plant hopper, leaf folder, BPH, WBPH.
DRR Dhan 73 (IET 30242)	Karnataka, Odisha and Telangana	Suitable for irrigated and rainfed shallow lowland areas with low soil P for both *kharif* and *rabi*, average grain yield 60 q/ha (under normal conditions; 60 kg/ha of P, i.e. recommended dose), 40 q/ha (under low P; 40 kg/ha of P) and 40.0 q/ha (under low P; 0 kg/ha of P), maturity 120-125 days, moderately resistant to leaf blast.
DRR Dhan 74 (IET 30252)	Karnataka, Maharashtra, Telangana, Jharkhand, and regions with P deficit soil of India	Suitable for irrigated and rainfed shallow lowland areas with low soil P for both *kharif* and *rabi*, average grain yield 70 q/ha (under normal conditions; 60 kg/ha of P, i.e. recommended dose), 44 q/ha (under low P; 40 kg/ha of P) and 45.6 q/ha (under low Phosphorus; 0 kg/ha of P), maturity 130-135 days. Moderately tolerant to leaf blast, neck blast, sheath rot, plant hoppers.
DRR Dhan 75 (IET 30107)	Telangana, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Odisha, Jharkhand, Bihar, Gujarat and Maharashtra	Suitable for medium duration irrigated *kharif*, average grain yield 60 q/ha, maturity 135-140 days, lodging resistance, MAS derived variety in the background of Samba Mahsuri with introgression of *OsSPL14+Gn1a+ SCM2*, resistant to neck blast, moderately resistant to leaf blast.
DRR Dhan 76 (IET 29808)	Odisha, West Bengal, Kerala, Puducherry and Andhra Pradesh	Suitable for irrigated mid early duration, average grain yield 68 q/ha, maturity 120-125 days. Moderately resistant to leaf blast, neck blast. Resistant to brown plant hoppers.
DRR Dhan 77 (IET 28636)	Bihar, Gujarat and Tamil Nadu	Suitable for aerobic ecology, average grain yield 42 q/ha, maturity 135 days. Resistant to leaf blast, neck blast. Moderately resistant to brown spot.
DRR Dhan 78 (IET 30240)	Karnataka and Telangana	Suitable for irrigated and rainfed shallow lowland areas with low soil P for both *kharif* and *rabi*, average grain yield 58 q/ha (under normal conditions; 60 kg/ha of P, i.e. recommended dose), 46 q/ha (under low P; 40 kg/ha of P) and 40.0 q/ha (under low Phosphorus; 0 kg/ha of P), maturity 120-125 days. Moderately resistant to leaf blast and plant hoppers.
DRR Dhan 79 (IET 29859)	Odisha, Bihar, Chhattisgarh, Madhya Pradesh, Maharashtra, Karnataka and Tamil Nadu	Suitable for irrigated medium duration ecology, average grain yield 57 q/ha, maturity 125-130 days, MAS derived variety in the background of Krishna Hamsa with introgression of *Pi54+ Bph20+Bph21.* Resistant to leaf blast, neck blast. Moderately resistant to BPH, gallmidge, drought tolerant.
DRR Dhan 80 (IET 30757)	Karnataka and Telangana	Suitable for medium duration irrigated *kharif*, average grain yield 67 q/ha, maturity 130-135 days, MAS derived NIL entry of Gangavati Sona introgressed with bacterial leaf blight resistance (*xa5+xa13+Xa21*), enhanced resistance to BLB over the recurrent parent.
BRR 2152 (Sabour Pratap Dhan) (IET 30083)	Bihar, Jharkhand, Odisha, Uttar Pradesh, Chhattisgarh, Maharashtra, Gujarat, Telangana, Karnataka, Andhra Pradesh and Tamil Nadu	Suitable for irrigated-Medium slender transplanted conditions, average grain yield 60.1 q/ha, maturity 130-135 days, moderately resistant to leaf blast and plant hoppers.
BRR 2183 (Sabour Vijay Dhan) (IET 30029)	Bihar, Jharkhand Chhattisgarh and Karnataka	Suitable for aerobic conditions, average grain yield 42.6 q/ha, maturity 130-135 days, moderately resistant to leaf blast and plant hoppers.
BRR 2184 (Sabour Narendra Dhan)	Bihar, Uttar Pradesh and Chhattisgarh	Suitable for aerobic conditions, average grain yield 44.2 q/ha, maturity 120-125 days, moderately resistant to leaf blast.
BRR 2010 (Sabour Shriram Dhan) (IET 30367)	Bihar, Uttar Pradesh and Odisha	Suitable for rainfed shallow lowland conditions, average grain yield 47.9 q/ha, maturity 145-150 days. Moderate resistance to leaf blast.

Variety	Area of adoption	Salient features
27P34 (IET-29726) (PHI- 21103)	Odisha, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka and Puducherry	Suitable for irrigated, medium-early conditions, average grain yield 64.0 q/ha, maturity 125-130 days, moderately resistant to leaf blast and neck blast.
27P38 (IET-29734) (PHI- 21104)	Uttar Pradesh, Jharkhand, Maharashtra, Madhya Pradesh, Andhra Pradesh, Kerala	Suitable for irrigated, medium-early conditions, average grain yield 65.4 q/ha, maturity 125-130 days, moderate resistance to leaf blast.
OUAT Kalinga Rice 18 (Saria) ORJ 1342 (IET 29822) (TP 29409)	Odisha, Bihar and West Bengal	Suitable for irrigated medium land, high fertility *kharif* and *rabi* season, average grain yield 61.87 q/ha (zone III) and 61.05 q/ha (zone VII), maturity 130–135 days, non-lodging, moderately resistant to sheath rot, blasts, BPH.
RNC-0457/ NK4101 (IET-29738)	Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh and Kerala	Suitable for irrigated, medium-early conditions, average grain yield 64.7 q/ha, maturity 125-130 days. Moderates resistant to leaf blast and neck blast.
ADV 8222 (IET 29692)	Chhattisgarh and Maharashtra	Suitable for irrigated early conditions, average grain yield 62.1 q/ha, maturity 115-120 days. Moderate resistance to leaf blast, neck blast and brown spot.
ADV 8283 (IET 29690)	Bihar, Uttar Pradesh, Chhattisgarh, Maharashtra, and Madhya Pradesh	Suitable for irrigated early conditions, average grain yield 62.8 q/ha, maturity 120-125 days, moderate resistance to leaf blast and neck blast.
Arize Dhan DT (IET-29000) (HRI 205)	Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Madhya Pradesh, Chhattisgarh, Telangana, Andhra Pradesh. Tamil Nadu and Karnataka	Suitable for irrigated low land conditions, average grain yield 63.0 q/ha, maturity 135-140 days, moderate resistance to BLB and BPH.
Arize 655 ST (IET 29741) (HRI-209)	Haryana, Punjab, Uttar Pradesh, Bihar, Jharkhand, Odisha, Madhya Pradesh, Chhattisgarh, Maharashtra and Gujarat,	Suitable for irrigated medium conditions, average grain yield 66.8 q/ha, maturity 125-130 days, resistant to BLB and moderately resistant to Leaf blast.
HRI- 211 (2) (IET 29743)	Haryana, Punjab, Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Madhya Pradesh, Gujarat, Chhattisgarh and Maharashtra	Suitable for irrigated, medium conditions, average grain yield 66.0 q/ha, maturity 125-130 days, moderately resistant to BLB and BPH.
Arize 6585 ST (IET-29689) (HRI 214)	Haryana, Punjab, Uttar Pradesh, Bihar, Jharkhand, Odisha, Madhya Pradesh, Chhattisgarh, Maharashtra and Gujarat	Suitable for irrigated early conditions, average grain yield 66.0 q/ha, maturity 115-120 days. Moderately resistant to BLB, leaf blast, neck blast and brown spot.
Sanjeevani Rice	Chhattisgarh	Suitable for irrigated late conditions, average grain yield 35.4 q/ha, maturity 135-140 days, works as an immunity booster and prevention of cancer cells.
Bauna Luchai-CTLM (Chhattisgarh Trombay Luchai Mutant)	Chhattisgarh	Suitable for irrigated early transplanted conditions, average grain yield 43.9 q/ha, maturity 110-115 days. Moderately resistant to leaf blast, neck blast, stem borer (white ear head). Resistant to stem borer (dead heart).
Sahyadri Siri	Karnataka Zone 7	Suitable for irrigated late conditions, average grain yield 62.1 q/ha, maturity 135 days. Moderately resistant to leaf blast, neck blast. Moderately tolerant to stem borer.
Sahyadri Jalmukthi (KHP-14/IET 30872)	Karnataka Zone 9	Suitable for rainfed late conditions, average grain yield 49.8 q/ha, maturity 145 days, moderately tolerant to submergence, stem borer. Moderately resistant to leaf blast, neck blast.
Sahyadri Sapthami (BMR-US-1-24-2)	Karnataka Zone 10	Suitable for irrigated mid-early conditions, average grain yield 57.0 q/ha, maturity 120-125 days. Tolerant to leaf blast, neck blast, false smut, brown leaf spot and gall midge.
KMP-225	Karnataka Zone 6	Suitable for irrigated medium conditions, average grain yield 60.0 q/ha, maturity 120-125 days. Moderately resistant to leaf and neck blast, and brown plant hoppers.
Kaje 25-9 (BMR-Kajejaya) (IET 30120)	Karnataka Zone 10	Suitable for irrigated medium conditions, average grain yield 50.8 q/ha, maturity 120-125 days. Tolerant to leaf blast, neck blast and gall midge.
CG Tejas Dhan (IGKV DH Rice 2)	Chhattisgarh	Suitable for irrigated medium-transplanted conditions, average grain yield 55.0 q/ha, maturity 125-130 days. Moderately resistant to bacterial leaf blight, neck blast, sheath rot and leaf blast.
CAU-R 105 (Khingrasong 1) (IET 27496)	Meghalaya	Suitable for irrigated low and medium attitude conditions, average grain yield 30.4 q/ha, maturity 135-140 days, low phosphorus tolerance, higher yield under acidic soil. Resistant to leaf blast and neck blast.

Variety	Area of adoption	Salient features
CAU-R 107 (Khingrasong 2) (IET 28210)	Meghalaya	Suitable for irrigated low and medium attitude conditions, average grain yield 46.1 q/ha, maturity 120-125 days, low phosphorus tolerance, higher yield under acidic soil. Resistant to leaf blast and neck blast.
CAU-R 124 (Khingrasong 3) (IET 28907)	Meghalaya	Suitable for irrigated low and medium attitude conditions, average grain yield 43.7 q/ha, maturity 130 days, low phosphorus tolerance, higher yield under acidic soil. Resistant to leaf blast and neck blast.
Phule Kolam (VDN 1832)	Maharashtra	Suitable for irrigated medium slender transplanted conditions, average grain yield 46.6 q/ha, maturity 125-130 days. Moderately resistant to leaf blast, neck blast, sheath rot, grain discolouration. Resistant to brown spot (hotspots in Maharashtra) and stem borer (hotspots in Maharashtra).
Pant Sugandh Dhan 25	Uttarakhand	Suitable for irrigated aromatic conditions, average grain yield 45.3 q/ha, maturity 135-140 days, moderately resistant BLB, tolerant to stem borer.
RYT 3888 (PR 131)	Punjab	Suitable for irrigated medium transplanted conditions, average grain yield 51.8 q/ha, maturity 135-140 days. Resistant to BLB. Tolerant to stem borer, leaf folder and white backed plant hopper.
Konkon Sanjay KJTR 3 IET 29264	Maharashtra	Suitable for irrigated medium transplanted conditions, average grain yield 48.3 q/ha, maturity 125-130 days. Moderately resistant to leaf blast, stem borer.
Trombay Konkon Khara (BARCKKV 16) (IET 30185)	Maharashtra	Suitable for coastal saline soils, average grain yield 37-41 q/ha, maturity 125-130 days, moderately resistant to BLB, tolerant to stem borer.
Shalimar Rice-7 (SKUA 540)	Jammu and Kashmir	Suitable for double cropping with sarson crop, highly recommended for low altitudes of Jammu and Kashmir (from 1,590-17,00 m amsl), average grain yield 8.0-8.5 t/ha, maturity 135-140 days, lodging and shattering resistant. Moderately resistant to leaf blast, neck blast, brown spot. Resistant to grasshopper, rice skipper.
Shalimar Rice-8 (SKUA 522)	Jammu and Kashmir	Suitable for irrigated early mid altitudes of Jammu and Kashmir (from 1,750-1,900 m amsl), average grain yield 51.7 q/ha, maturity 130-135 days. Moderately resistant to leaf blast, neck blast, brown spot. Resistant to grasshopper, rice skipper.
Shalimar Rice-9 (SKUA 493)	Jammu and Kashmir	Suitable for irrigated early hills of Kashmir valley (up to the altitude of 2,200 m amsl), average grain yield 41.7 q/ha, maturity 130-135 days. Moderately resistant to leaf blast, neck blast, brown spot. Resistant to grasshopper, rice skipper.
Labanga Dhan (CR Dhan 603)	Odisha	Suitable for irrigated *Boro/dalua (*summer rice), average grain yield 58.8 q/ha, maturity 130-140 days, long slender grain. Resistant to false smut, leaf folder, stem borer (dead heart and white ear head), gall midge. Moderately resistant to blast, sheath rot, brown spot, BPH.
Pusa 1824 (IET 28442)	NCT of Delhi	Suitable for irrigated mid-early conditions, average grain yield 53.2 q/ha, maturity 120-125 days, long slender grain. Moderately resistant to blast, neck blast, sheath rot, brown spot. Tolerant to stem borer.
Pusa 2090 (IET 29217)	NCT of Delhi	Suitable for irrigated mid-early conditions, average grain yield 53.8 q/ha, maturity 125-130 days, resistant to neck blast. Moderately resistant to blast, brown spot. Tolerant to stem borer, leaf folder.
ADT 59 (IET 29154)	Tamil Nadu	Suitable for irrigated early conditions, average grain yield 61.0 q/ha, maturity 110-115 days, resistant to sheath blight, blast and RTD. Moderately resistant to bacterial leaf blight, sheath rot, false smut. Resistant to stem borer, leaf folder, gall midge.
KKM 1 (IET 30079)	Tamil Nadu	Suitable for irrigated mid-early conditions, average grain yield 61.0 q/ha, maturity 115-120 days. Moderately resistant to blast, BLB, sheath blight, sheath rot. Resistant to stem borer, leaf folder.
CO 58 (IET 25577)	Tamil Nadu	Suitable for irrigated mid-early conditions, average grain yield 58.6 q/ha, maturity 120-125 days, resistant to sheath blight. Moderately resistant to rice tungro, sheath rot, brown spot, false smut, blast, WBPH, GLH.
CO-57 (IET 31924)	Tamil Nadu	Suitable for irrigated medium condition (late Samba and Thaladi seasons), average grain yield 46.3 q/ha, maturity 130-135 days. Resistant to BLB, sheath blight, false smut. Moderately resistant to sheath rot, brown spot, grain discolouration, stem borer, leaf folder.
CO RH 5 (IET 24986)	Tamil Nadu	Suitable for irrigated medium condition (late Samba and Thaladi seasons), average grain yield 64.7 q/ha, maturity 120-125 days. Moderately resistant to leaf blast, neck blast, grain discolouration, BPH, stem borer.

Variety	Area of adoption	Salient features
Wheat		
HD 3388	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, (excluding hills), Odisha and Assam	Suitable for irrigated and timely sown conditions, average grain yield 52.0 q/ha, maturity 125 days, tolerant to heat stress (HSI 0.89), chapati score (8.0) along with good grain hardness index (68.5) indicating better chapati quality.
Pusa Wheat 3386 (HD 3386)	Punjab, Haryana, Delhi, Rajasthan (Except Kota and Udaipur Divisions), Western Uttar Pradesh (Except Jhansi Division), Parts of Jammu and Kashmir (Kathua district), parts of Himachal Pradesh (Una district and Paonta Valley) and Uttarakhand (Tarai region)	Suitable for irrigated and timely sown conditions, average grain yield 62.5 q/ha, maturity 145 days, resistant to leaf and yellow rust, rich in iron (41.1 ppm) and zinc (41.8 ppm).
HD 3410 (Pusa Jawahar Gehun 3410)	Madhya Pradesh, Delhi and NCR region of Haryana, Uttar Pradesh	Suitable for irrigated early sown conditions, average grain yield 65.91 q/ha, maturity 130 days, high protein content (12.6%), resistant to rust diseases and Karnal bunt.
Badshah (NWS 2194)	Madhya Pradesh, Chhattisgarh, Gujarat and Rajasthan	Suitable for timely sown irrigated conditions, average grain yield 57.8 q/ha, maturity 120 days, resistant to black and brown rust, heat tolerant (HIS 0.97).
Karan Bold (DBW 377)	Madhya Pradesh, Chhattisgarh, Gujarat and Rajasthan	Suitable for irrigated early sown condition, average grain yield 63.9 q/ha, maturity 125 days, resistant to wheat blast.
Karan Shivangi (DBW 359)	CZ - Madhya Pradesh, Chhattisgarh, Gujarat Rajasthan	Suitable for irrigated condition, average grain yield 41.7 q/ha, maturity 115 days, high protein content (12.6%). Highly resistant to stem rust, leaf rust and wheat blast.
	PZ - Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana	Suitable for irrigated condition, average grain yield 32.5 q/ha, maturity 105 days. Highly resistant to stem rust, leaf rust and wheat blast.
GW 547	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	Suitable for irrigated timely sown condition, average grain yield 58.2 q/ha, maturity 120 days. High in iron (~42.0 ppm), zinc (~45.4 ppm) and protein (12.6%). Tolerant to heat and drought (HIS-0.88 and DSI-0.90), high levels of resistance to stem rust.
Krishidhara Surya (UAS 478)	Maharashtra and Karnataka	Suitable for timely sown, restricted irrigation condition, average grain yield 31.99 q/ha, maturity 107 days, high zinc (38.1 ppm) and iron content (37.8 ppm), drought tolerant variety, presence of high yellow pigment (7.7 ppm) makes it more suitable to pasta products.
Phule Anurag (NIAW 4028)	Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu (except Nilgiris and Palani Hills)	Suitable for restricted irrigation, timely sown condition, average grain yield 33.43 q/h, maturity 106 days, high protein (12.43%) and iron content (39.7 ppm). Resistant to brown rust, black rust.
MP (JW) 1378	Maharashtra and Karnataka plains of Tamil Nadu	Suitable for irrigated timely sown condition, average grain yield 52.5 q/h, maturity 105 days. Rich in protein (12.6%), iron (40.5 ppm) and zinc (42.8 ppm) content.
Mavanti (CG 1040)	Madhya Pradesh, Gujarat, Chhattisgarh, Kota and Udaipur Divisions of Rajasthan and Jhansi Division of Uttar Pradesh	Suitable for restricted irrigation timely sown condition, average grain yield 42.7 q/ha, maturity 118 days, tolerant to drought (DSI=0.87) and heat (HSI=0.89).
WH 1402	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua distt.) and parts of Himachal Pradesh (Una distt. and Paonta valley) and Uttarakhand (Tarai region)	Suitable for timely sown restricted irrigation conditions, average grain yield 50.25 q/ha, maturity 147 days. Resistant to stripe rust, leaf rust and flag smut.
HD 3390	Delhi	Suitable for irrigated timely sown conventional tillage and conservation agriculture environments, average grain yield 62.36 q/ha, maturity 144 days, rich in protein (12.4%), highly resistant to all three rusts (stripe rust, leaf rusts, stem rust), tolerant to lodging.
Pusa Gehun Sharbati (HI 1665)	Maharashtra, Karnataka and Plains of Tamil Nadu	Suitable for timely sown, restricted irrigated condition, average grain yield 33.0 q/ha, maturity 110 days, tolerant to heat and drought (heat sensitivity index 0.98 and drought sensitivity index 0.91), excellent grain quality, bio-fortified with higher grain zinc content (40.0 ppm), resistant to leaf and stem rust.

Variety	Area of adoption	Salient features
Pusa Gehun Gaurav (HI 8840)	Maharashtra, Karnataka and plains of Tamil Nadu	Suitable for irrigated conditions, durum wheat variety, average grain yield 30.2 q/ha, terminal heat tolerant, resistant to stem and leaf rusts. Biofortified with higher zinc (41.1 ppm) and iron (38.5 ppm), and protein content (~12%).
Krishidhara Krishna Super DWK 1063 (DDK 1063)	Karnataka Zone-3 and 8	Suitable for irrigated timely sown conditions, average grain yield 48.28 q/ha, maturity 106 days, lodging tolerant, resistant to black and brown rust. Biofortified dicoccum wheat with good amount of protein (14.4%), iron (43.7 ppm) and zinc (45.3 ppm).
HD 3437	Delhi state and NCR	Suitable for timely sown irrigated conditions, average grain yield 53.95 q/ha, maturity 144 days. Developed through marker assisted backcross breeding (MABB) through transfer of leaf rust resistance gene Lr34 and stripe rust resistance gene Yr10 in wheat variety HD 2967 (recurrent parent). Resistant to leaf and stripe rusts, protein 12.4%, Fe 37.1 ppm, Zn 37.7 ppm.
MP 3535 (JW 3535)	Madhya Pradesh	Suitable for irrigated timely sown condition, average grain yield 59.1 q/ha, maturity 115-120 days, non-lodging, highly resistant to black and leaf rusts. High protein (11.7%), Zn (44.15 ppm) and Fe (39.9 ppm.
TJW 153 (Trombay Jodhpur Wheat 153)	Rajasthan	Suitable for irrigated, timely sown medium fertile soil conditions during *rabi*, average grain yield 50.0 q/ha, maturity 126 days, highly responsive to fertilizer and irrigation, iron rich (39.9 ppm). Resistant to leaf rust, stem rust. High degree of resistance to Karnal bunt, loose smut, flag smut and powdery mildew. No major insect pest infestation.
TRVW 155 (Trombay Raj Vijay Wheat 155)	Madhya Pradesh	Suitable for irrigated, timely sown conditions, average grain yield 57.4 q/ha, maturity 123 days, heat stress tolerant. Resistant to wheat blast, stripe rust, stem rust and leaf rust, karnal bunt, loose smut, powdery mildew and foot root.
PBW RS1 (WBL 1521)	Punjab	Suitable for irrigated, timely sown conditions, average grain yield 42.65 q/ha, maturity 146 days, highly resistant to yellow and brown rust. High resistant starch, owing to decreased digestibility of starch, lowering of the glycemic index happens.
PBW Zinc 2 (PBW 823)	Punjab	Suitable for irrigated, timely sown conditions, average grain yield 52.2 q/ha, maturity 154 days, biofortified with good amount of zinc (48.5 ppm) and Fe (44.2 ppm), resistant to yellow and bown rust.
Maize		
JKMH 4243	Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	Suitable for cultivation during *kharif* season under irrigated conditions, average grain yield 95.00 q/ha, medium maturity 96-98 days. Moderate resistance to maydis leaf blight, turcicum leaf blight and charcoal rot.
ADV 768 (ADV 7251)	Karnataka, Maharashtra, Tamil Nadu, Telangana, Andhra Pradesh, Rajasthan, Madhya Pradesh, Gujarat and Chhattisgarh	Suitable for cultivation during *kharif* season under irrigated conditions, average grain yield 95.00 q/ha, maturity (110-115 days). Moderately resistant to turcicum leaf blight, **c**harcoal rot and fusarium stalk rot. Moderate tolerance against *Chilo partellus* and foliar damage by fall armyworm. Resistant to ear damage by FAW.
Pant Composite Maize 4 (PCM 4) (DOP-339)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura	Suitable for cultivation during *kharif* season under irrigated and rainfed conditions, average grain yield 58.84 q/ha, early maturity 90-95 days, moderately resistant to TLB and BLSB under artificial inoculation, infestation average score of 4.64 on 1-9 scale against *Chilo partellus*.
VL Madhurima (FSCH 144)	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Maharashtra, Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Odisha and Chhattisgarh	Suitable for cultivation during *kharif* season under rainfed conditions, average grain yield 68.51 q/ha, early maturity 95-100 days, moderately resistant against turcicum leaf blight, fusarium stalk rot, charcoal rot and cercospora leaf spot.
VL VitA (FPVH 1)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura	Suitable for cultivation during *kharif* season under rainfed conditions, average grain yield 68.51 q/ha, maturity 95-100 days, moderate resistance against *H. turcicum*, leaf blight, biofortified hybrid with high Provitamin A (7.48 µg/g).
R 3414 (RMH 3414)	Maharashtra, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	Suitable for cultivation during *kharif* season under irrigated and rainfed conditions, average grain yield 101.58 q/ha, late maturity 120-130 days. Moderately resistant to TLB, BLSB, charcoal rot, *Chilo partellus* and fall armyworm (FAW).
Shalimar Kishenganga 3 (KDM 30)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Manipur, Meghalaya and Assam	Suitable for cultivation during *kharif* season under irrigated and rainfed conditions, average grain yield 54.40 q/ha, early maturity 100 days. Moderately resistant to TLB, *Chilo partellus* and *Spodoptera frugiperda*.

Variety	Area of adoption	Salient features
IBCH 401 (IMHSB 19KB-2)	Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana, Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Suitable for cultivation in during *kharif* season under irrigated conditions, average grain yield 15.83 q/ha, maturity 57 days. Moderately resistant to stem borer (*Chilo partellus),* fall armyworm (*Spodoptera frugiperda*) insects, curvularia leaf spot, turcicum leaf blight, fusarium stalk rot and charcoal rot.
ISCH 601 (ISCH 1901)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha and West Bengal.	Suitable for cultivation during *kharif* season under irrigated conditions, average grain yield 105.10 q/ha, maturity 90-95 days. Moderately resistant to curvularia leaf spot, banded leaf and sheath blight. Moderately tolerant to *Chilo partellus* and foliar damage by fall armyworm.
IPCH 501 (IPCH 1901)	Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Karnataka and Kerala	Suitable for cultivation during *kharif* season under irrigated conditions, average grain yield 43.77 q/ha, maturity 90-95 days. Moderately resistant to turcicum leaf blight.
QPMH 6 (EDV of PMH 6)	Bihar, West Bengal, Jharkhand, Odisha and Uttar Pradesh (Eastern region)	Suitable for cultivation during *kharif* season under irrigated conditions, average grain yield 64.17 q/ha, maturity 95-105 days, moderately resistant to a major disease of the NEPZ.
IMH 225 (IMHSB 17R-16)	Punjab, Haryana, Uttar Pradesh (Western region), Uttarakhand (Plains) and Delhi	Suitable for cultivation during *rabi*/spring under irrigated conditions, average grain yield 102.5 q/ha, maturity 155-160 days. Moderately resistant to stem borer (*Chilo partellus),* pink stem borer (*Sesamia inferens) and* fall armyworm (*Spodoptera frugiperda*) insects. Resistant to maydis leaf blight, fusarium stalk rot, charcoal rot, turcicum leaf blight.
IMH 226 (IMHSB 17R-17)	Punjab, Haryana, Uttar Pradesh (Western region), Uttarakhand (Plains) and Delhi	Suitable for cultivation during *rabi*/spring under irrigated conditions, average grain yield 98.9 q/ha, medium maturity *rabi* 154-157 days. Moderately resistant to stem borer (*Chilo partellus),* pink stem borer (*Sesamia inferens) and* fall armyworm (*Spodoptera frugiperda*) insects. Resistant to fusarium stalk rot and maydis leaf blight, charcoal rot, turcicum leaf blight.
IMH 227 (IMHSB 19R-2)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha and West Bengal	Suitable for cultivation during *rabi* season under irrigated conditions. Average grain yield 109.1 q/ha, medium maturity 143-150 days. Moderately resistant to fall armyworm (*Spodoptera frugiperda*) insect, maydis leaf blight, charcoal rot, turcicum leaf blight. Highly responsive to high nutrient inputs.
IMH 228 (IMHSB 19R-10)	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal and Telangana	Suitable for cultivation during *rabi* under irrigated conditions, average grain yield 105.7 q/ha, medium maturity 143-150 days. Moderately resistant to fall armyworm (*Spodoptera frugiperda*) insect, maydis leaf blight, charcoal rot, turcicum leaf blight.
CP Sweet 2	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh	Suitable for cultivation during *kharif* under irrigated and rainfed conditions, average cob yield 146.88 q/ha, maturity 70-75 days. Highly resistant to charcoal rot, MLB, TLB, BLSB under natural field. Moderately resistant to *Chilo partellus* under natural conditions, with comparable performance under artificial infestation; less leaf damage to fall armyworm (*Spodoptera frugiperda*) under artificial condition.
KMH 8121 (HM 20105)	Uttar Pradesh, Bihar, West Bengal, Odisha, Chhattisgarh and Jharkhand	Suitable for cultivation during *kharif* under irrigated conditions, yield 69.46 q/ha, medium maturity 89-93 days. Moderately resistant to MLB, *Chilo partellus and* fall armyworm.
KMH 8577 (KMH 018)	Andhra Pradesh, Telangana, Maharashtra, Karnataka and Tamil Nadu	Suitable for cultivation during *rabi* under irrigated conditions, average grain yield 69.46 q/ha. Late maturity 106-110 days. Moderately resistant to TLB, charcoal rot, SDM, *Sesamia inferense, Chilo partellus* and fall armyworm (FAW).
DKC 8211 (IU8229)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh	Suitable for cultivation during *kharif* under irrigated conditions, average grain yield 83.09 q/ha, medium maturity 104 days. Moderately resistant to TLB, BLSB, BSR, *Chilo partellus* and stem borer.
DKC 9215 (IU8636)	Rajasthan, Madhya Pradesh, Chhattisgarh and Gujarat	Suitable for cultivation during *kharif* under irrigated conditions, average grain yield 83.09 q/ha, late maturity 115-20 days. Moderately resistant to FSR, CLS and *Chilo partellus.*
GK 3302	Punjab, Haryana, Delhi, Uttarakhand, Western Uttar Pradesh	Suitable for cultivation during *kharif* under irrigated conditions, average grain yield 91.22 q/ha, late maturity 130-135 days. Moderately resistant to all major diseases, viz. MLB, BLSB, *Chilo partellus* and FAW.
GK 3303	Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh	Suitable for cultivation during *kharif* under irrigated conditions, average grain yield 88.59 q/ha, late maturity 130-135 days. Moderately resistant to all major diseases, viz. MLB, *Chilo partellus* and FAW.
DHM 206 ((Telangana Makka-3) (BH 417206)	Punjab, Haryana, Uttarakhand, plains Uttar Pradesh Western region, Delhi, Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region) and West Bengal	Suitable for cultivation during *kharif* under irrigated conditions, average grain yield 84.82 q/ha, late maturity 105-110 days. Moderately resistant to turcicum leaf blight, maydis leaf blight, charcoal rot, banded leaf and sheath blight, Rajasthan downy mildew, sorghum downy mildew, fusarium stalk rot, curvularia leaf spot, fall armyworm (*Spodoptera frugiperda)* as well as *Chilo partellus.*

Variety	Area of adoption	Salient features
Pratap Hybrid-6 (EH 2936)	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh	Suitable for cultivation in CWZ during *kharif* under irrigated conditions, average grain yield 62.06 q/ha, early maturity 85 days. Moderately resistant to major diseases like MLB, TLB, PFSR and RDM.
CP.999	Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh (Western region)	Suitable for irrigated *kharif*, yield 108 q/ha, maturity 100-110 days. Resistant to Turcicum leaf blight, charcoal rot. Moderately resistant to Maydis leaf blight, banded leaf, sheath blight, *Chilo partellus*, fall armyworm (*Spodoptera frugiperda*).
IBCH 402 (IBH 11-227)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand (Hill region), Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur and Arunachal Pradesh	Suitable for *kharif* irrigated conditions for Northen hill zones, average baby corn yield with husk 76.42 q/ha, without husk 24.60 q/ha, fodder yield 29.1 t/ha, maturity 90-95 days, cytoplasmic male sterile EDV hybrid, moderately tolerant to major diseases and insect-pests.
IMH 230 IMHSB 20R-6	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal	Suitable for irrigated *rabi* season, average grain yield 92.36 q/ha, maturity 145.2 days. Moderately resistant to biotic stresses, MLB, ChR and TLB. Moderately tolerant to *Chilo partellus,* fall armyworm.
IMH 231 IMHSB 20K-10	Eastern Uttar Pradesh, Bihar, Jharkhand, Odisha, West Bengal, Assam	Suitable for *kharif* irrigated condition, average grain yield 70.28 q/ha, maturity 90 days. Moderately tolerant to waterlogging, tolerant to lodging. Moderately resistant to TLB, MLB. Resistant to FSR. moderately tolerant to *Chilo partellus*, fall armyworm.
VNR 4597	Karnataka, Andhra Pradesh, Telangana, Maharashtra and Tamil Nadu	Suitable for irrigated *rabi* season, average grain yield 108 q/ha, maturity 125-130 days (late). Moderately resistant to Turcicum leaf blight, charcoal rot, spotted stem borer and fall armyworm.
P 34407 (PM-21111 L)	Punjab, Madhya Pradesh, Delhi, Rajasthan, Uttarakhand and Gujarat	Suitable for rainfed *kharif* season, average grain yield 90 q/ha, maturity 125-135 days (late). Moderately resistant to Turcicum leaf blight, Maydis leaf blight, *Fusarium* stalk rot, banded leaf, sheath blight, *Chilo partellus*, fall armyworm.
P 3319 (PM-20205 L)	Andhra Pradesh, Telangana, Maharashtra, Karnataka, Tamil Nadu, Rajasthan, Madhya Pradesh and Gujarat	Suitable for rainfed *kharif* season, average grain yield 90 q/ha, maturity 125-135 days (late). Moderately resistant to Turcicum leaf blight, Maydis leaf blight, *Fusarium* stalk rot, banded leaf, sheath blight, *Chilo partellus*, fall armyworm.
Bio 207 (Bioseed 9577)	Karnakata, Tamil Nadu	Suitable for irrigated *rabi* season, average grain yield 103 q/ha, maturity 100 - 105 days. Moderately resistant to Turcicum leaf blight, charcoal rot and *Chillo partellus*.
Pusa Popcorn Hybrid – 1 (APCH 2)	Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh (Western region), Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu	Suitable for irrigated *rabi* ecology, average grain yield 46.04 q/ha (NWPZ), 47.17 q/ha (PZ), maturity 120.2 days (NWPZ), 102.1 days (PZ), higher popping percentage (97.3% in NWPZ and 98.3% in PZ) and popping expansion ratio (18), resistant/moderately resistant to charcoal rot.
Pusa Popcorn Hybrid – 2 (APCH 3)	Maharashtra, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	Suitable for irrigated *rabi* season, average grain yield 45.13 q/ha, maturity 102.5 days, moderately resistant to TLB.
Pusa Bio fortified Maize Hybrid – 4 (APH4)	Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh (Western region), Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat, Madhya Pradesh, Chhattisgarh, Rajasthan	Suitable for *kharif* season, average grain yield 84.33 q/ha (NWPZ), 71.13 q/ha (PZ), 56.58 q/ha (CWZ). Maturity 79.8 days (NWPZ), 93.9 days (PZ), 86.4 days (CWZ). Rich in provitamin-A (6.7 ppm), lysine (3.47%) and tryptophan (0.78%). Moderately resistant to MLB, BLSB, TLB.
Pusa Biofortified Maize Hybrid-5 (APTQH-5)	Punjab, Haryana, Delhi, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region), West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat, Madhya Pradesh, Chhattisgarh and Rajasthan	Suitable for irrigated *kharif* season, average grain yield 70 q/ha, maturity 94 days. Rich in α-tocopherol/vitamin-E (21.60 ppm), provitamin-A (6.22 ppm), lysine (4.93%) and tryptophan (1.01%). Moderately resistant to TLB, charcoal rot, *Chilo partellus*, fall armyworm.
Pusa HM4 Male Sterile Baby Corn-2 (ABSH4 2)	Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region), West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat, Madhya Pradesh, Chhattisgarh, Rajasthan	Suitable for irrigated conditions during *kharif* season. Average baby corn yield 19.56 q/ha (NEPZ), 14.07 q/ha (PZ) and 16.03 q/ha (CWZ). Maturity 53 days, 100% male sterility, no anther exertion, resistant/moderately resistant to charcoal rot.
MAH 14-138	Karnataka (Zone-5 and 6)	Suitable for irrigated/ rainfed ecology in both *kharif* and *rabi*-summer conditions, average grain yield 85-90 q/ha (*kharif*), 95-100 q/ha (*rabi*-summer), maturity 115-120 days, resistant to TLB, moderately resistant to SDM disease, tolerant to aphid infestation.

Variety	Area of adoption	Salient features
Rajendra Baby Corn 1 (MBC-11-15)	Bihar	Suitable for irrigated *kharif* conditions, average grain yield 12.70 q/ha, maturity 50 to 60 days, tolerant to water scarcity. Moderately resistant to Maydis leaf blight, banded leaf and sheath blight.
Rajendra Pop Corn 1 (MPC-1-15)	Bihar	Suitable for irrigated *kharif* conditions, average grain yield 31.24 q/ha, maturity 87 to 90 days, tolerant to water scarcity. Moderately resistant to Maydis leaf blight, banded leaf and sheath blight.
PDKV Aarambha (BMH 18-2)	Maharashtra	Suitable for *kharif* timely sown rainfed condition, average grain yield 101 q/ha, maturity 95-100 days. Moderately resistant to Turcicum leaf blight, *Chilo partellus*. Tolerant to *Spodoptera furgiperda* (fall armyworm) ear damage.
PMH 14 (JH 17011)	Punjab	Suitable for irrigated *kharif* season, average grain yield 69 q/ha, maturity 98 days, moderately tolerant to fall armyworm.
AH-8181 Pusa Jawahar Hybrid Maize (R) – 3 **(**PJHM(R)-3)	Madhya Pradesh	Suitable for irrigated *rabi* condition, average grain yield 91.98 q/ha, maturity 125 days, stay green nature with very good fodder value, tolerant to drought, resistant to lodging, resistant to *Fusarium* stalk rot. Moderately resistant to *Turcicum* leaf blight, maydis leaf blight, Tolerant to stem borer, fall armyworm.
Phule Umed QMH 1701 (QMI 1531 × QMI 1651)	Maharashtra	Suitable for *kharif*, medium to heavy soil type. Average grain yield 80–85 q/ha, maturity 95–100 days. Resistant to Turcicum leaf blight (TLB), Maydis leaf blight (MLB), Curvularia leaf spot (CLS), rust and stem borer (*Chilo partellus*). Moderately resistant to FAW (*Spodoptera frugiperda*).
QMH 1819 Phule Champion	Maharashtra	Suitable for *kharif*, medium to heavy soil type, average grain yield 85–90 q/ha, maturity 90–95 days. Resistant to Turcicum leaf blight (TLB), Maydis leaf blight (MLB), Curvularia leaf spot (CLS), rust, stem borer (*Chilo partellus*). Moderately resistant to fall armyworm.
IMH 229 (DMRH 1410)	West Bengal	Suitable for *rabi* irrigated/*kharif* and spring. Average grain yield 95-100 q/ha *(rabi*), 70-75 q/ha (*kharif)*, 85 to 90 q/ha (Spring), maturity 145-150 days (*rabi*), 90-95 days (*kharif*), 120-125 days (Spring). Resistant to downy mildew, maydis leaf blight, curvularia leaf spot, *Fusarium* stalk rot. Tolerant to stem borer (*Chilo partellus*), suitable for silage and fodder maize cultivation.
AH-7154 Pusa Shalimar Maize Hybrid-1	Jammu and Kashmir	Suitable for low to medium elevations of Kashmir valley between 1550-1850 m above mean sea level in irrigated/rainfed ecology, average grain yield 82.15 q/ha, maturity 125-130 days. Resistant to bacterial stalk rot (BSR), Curvularia leaf spot (CLS), Rajasthan downy mildew (RDM). Moderately resistant to Maydis and *Turcicum* leaf blight, stem borer and aphid.
VL Shikhar (FLPH 19)	Uttarakhand (Hills)	Suitable for rainfed agro-ecosystem in *kharif* and well-performing in mid-hills, average grain yield 52.18 q/ha, maturity 90-95 days, low phytate (2.20 mg/g), EDV of Vivek Maize Hybrid 53 leads to enhancing the bioavailability of Fe and Zn, high responsiveness to inorganic fertilizers, moderate resistance against *H. turcicum* leaf blight, tolerant to major pests.
VL Poshika (FQH 160)	Uttarakhand (Plains)	Suitable for rainfed agro-ecosystem in *kharif* season, average grain yield 54.41 q/ha, maturity 90-95 days, biofortified QPM variety (tryptophan 0.71%, lysine 3.04%, protein 8.69%) developed through marker assisted backcross breeding (MABB), high responsiveness to inorganic fertilizers, moderately resistant against *H. turcicum* leaf blight, BLSB.
VL Triposhi (FQPLH 20)	Uttarakhand (Hills)	Developed by marker assisted backcross breeding (MABB). Suitable for organic conditions under rainfed agro-ecosystem during *kharif*, average grain yield 49.86 q/ha, maturity 90-95 days, triple biofortified QPM hybrid with 3.3 times higher provitamin A (6.63 µg/g), tryptophan (0.072%), lysine (0.297%), lower phytate (2.15 mg/g). Moderately resistant to *H. turcicum* leaf blight.
Maize VGIH (M) 2 (VaMH-12013)	Tamil Nadu	Suitable for cultivation in rainfed conditions during *rabi* season, average grain yield 63.52 q/ha, maturity 95 to 100 days, tolerant to drought. Moderately resistant to stem borer, fall armyworm, charcoal rot, *Turcicum* leaf blight.
Barley		
DWRB 219	Punjab, Haryana, Delhi, Rajasthan (excluding Kota and Udaipur division), Western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu and Kashmir, Paonta Valley and Una district of Himachal Pradesh and tarai region of Uttarakhand	Suitable for irrigated/ limited irrigation condition, average yield 54.49 q/ha, maturity 132 days, protein content 11.4%, resistant to yellow rust, moderately resistant to leaf rust, tolerant to lodging.

Variety	Area of adoption	Salient features
Sorghum		
CSV 55 (Gujarat Goti) (SPV 2776)	Gujarat, Madhya Pradesh and Karnataka	Suitable for rainfed condition during *kharif*, average grain yield 35 q/ha, dry fodder yield 160 q/ha, maturity 111 days. Moderately resistant to leaf and grain diseases, low incidence of shoot fly and stem borer.
CSV 58SS (SPV 2789)	Maharashtra, Telangana, Tamil Nadu, Punjab and Uttar Pradesh	Suitable for irrigated condition, fresh stalk yield 505 q/ha, maturity 114 days, sweet sorghum variety with high fresh stalk yield, juice yield, brix and computed ethanol yields, purple plant pigment with stay green character, resistant to leaf diseases.
CSV 59 BMR (SPV 2716)	Telangana, Tamil Nadu, Maharashtra, Gujarat, Haryana, Punjab, Rajasthan and Uttarakhand	Suitable for irrigated condition, average grain yield 38.7 q/ha, fodder yield 120 q/ha, maturity 115 days, brown midrib forage sorghum variety with high green and dry fodder yields.
CSV 60 Yellow (SPV 2620)	Maharashtra, Karnataka and Telangana	Suitable for irrigated condition, average grain yield 27 q/ha, fodder yield 119 q/ha, maturity 110 days (mid-late), bold grained bio-fortified yellow sorghum variety with high iron (31.6 ppm), zinc (24.4 ppm) and protein (12%), moderately tolerant to major pest and diseases.
Tandur Jonna 55 (SVT 55) (SPV 2644)	Telangana	Suitable for *rabi* season under residual soil moisture conditions in black soils of Telangana, dual purpose variety, average grain yield 24.5 q/ha, fodder yield 60-70 q/ha, maturity 115-120 days. Tolerant to shoot fly, aphids, fall armyworm and charcoal rot.
Gujarat Jowar-102 (Surat Goti)	Gujarat	Suitable for both *rabi* and *kharif* seasons, average grain yield 23.71 q/ha (*rabi* irrigated) and 74 q/ha of fodder yield, average grain yield 10.89 q/ha (*rabi* residual moisture) and 39 q/ha of fodder yield, average grain yield 25.35 q/ha (*kharif*), 139 q/ha of fodder yield, maturity (*kharif* 115 days, *rabi* 121 days).
SDAU Jowar Moti [Gujarat Jowar 45 (GJ 45)]	Gujarat	Suitable for irrigated/rainfed timely sown conditions, average grain yield 24.67 q/ha, fodder yield 159 q/ha, maturity 109 days. Moderately resistant to leaf blight, anthracnose, grain molds and ergot.
DSH-6 (CSH-49) (SPH1943)	Tamil Nadu, Karnataka, Telangana, Gujarat, Rajasthan	Suitable for rainfed *kharif* season, average grain yield 38.77 q/ha, fodder yield 116 q/ha, maturity early (100-105 days), non-lodging, fertilizer responsive, good stay green trait, moderately tolerant to grain mold disease, moderately susceptible to shoot fly.
Phule Purva (RSV 2371)	Maharashtra	Suitable for deep soil in *rabi* season, average grain yield 22-25 q/ha, dry fodder yield 65.0-80.0 q/ha, maturity 120-125 days, tolerant to drought and non-lodging, suitable for easy harvesting. Moderately resistant to shoot fly, stem borer, charcoal rot and leaf rust.
Pratap Jowar 2510 (SPV 2510)	Rajasthan	Suitable for rainfed situation, average grain yield 34-48 q/ha, dry fodder yield 135-138 q/ha, maturity 105-110 days. Moderately resistant to major foliar diseases, grain mold, shoot fly and stem borer.
CO 34 (SPV 2429)	Tamil Nadu	Suitable for both irrigated and rainfed conditions, average grain yield 27.65 q/ha (rainfed), dry fodder yield 94.78 q/ha, average grain yield 32.05 q/ha (irrigated), dry fodder yield 111.18 q/ha, maturity 100-105 days, non-lodging. Moderately resistant to shoot fly, stem borer, downy mildew and grain mold.
CO (SS) 33 (SPV 2895)	Tamil Nadu	Suitable for irrigated condition, average grain yield 25.00 q/ha, maturity 110-115 days, suitable for bioethanol production, green fodder, food grain and stover. Resistant to stem borer and anthracnose leaf disease.
Pearl millet		
Central Pearl Millet Hybrid MPMH 42 (Shree Anna Bajri 42) (MH 2553)	Drier part of Rajasthan, Gujarat and Haryana	Suitable for rainfed *kharif* season in dryer parts, average grain yield 21.13 q/ha, dry fodder yield 50 q/ha, maturity 75 days, high iron and zinc (Fe: 48 ppm, Zn: 37 ppm). Highly resistant to downy mildew (DM), blast and foliar diseases. Resistant to insect and pests and tolerant to drought.
Central Pearl Millet Hybrid GHB 1294 (Maru Moti) (MH 2555)	Drier part of Rajasthan, Gujarat and Haryana	Suitable for rainfed *kharif* season, average grain yield 22.23 q/ha, dry fodder yield 52 q/ha, maturity 78 days (early maturing). Rich in iron (53 ppm), zinc (37 ppm). Resistant to DM, blast and other foliar diseases. Tolerant to insects and pests and drought.
86M22 (MSH 377)	Summer growing areas of Gujarat, Maharashtra, Rajasthan, Punjab, Telangana Tamil Nadu, Uttar Pradesh, Andhra Pradesh	Suitable for normal summer season, average grain yield 48.16 q/ha, dry fodder yield 97 q/ha, late maturity (88 days). Rich in iron (61 ppm), zinc (39 ppm). Highly resistant to DM, ergot, smut, rust, blast, lodging. Highly responsive to fertilizers.
HT 4252 (MH 2577) (HBH 191294)	Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh and Delhi	Suitable for both early and late sown conditions, average grain yield 41.29 q/ha, dry fodder yield 108 q/ha, maturity late 80-85 days. Rich in iron (57 ppm), zinc (36 ppm). Resistant to stem borer, shoot fly and *Helicoverpa* larvae. highly resistant to DM and blast, tolerant to lodging.

Variety	Area of adoption	Salient features
PA 9898 (MSH 371 (PB 1879)	Gujarat, Rajasthan, Punjab, Uttar Pradesh, Maharashtra, Tamil Nadu and Telangana	Suitable for irrigated condition during summer season, average grain yield 47.57 q/ha, dry fodder yield 108 q/ha, late maturity 87 days. Rich in iron (47 ppm), zinc (32 ppm). Resistant to DM, blast, rust, smut, ergot. Tolerant to high temperature and lodging.
Banas Nayan (GHB 1351) (MSH 370)	Gujarat	Suitable for rainfed summer season, average grain yield 58.17 q/ha, dry fodder yield 83 q/ha, maturity late 83 days. Rich in iron (57 ppm), zinc (35 ppm). Resistant to DM and insect-pests, tolerant to abiotic stress.
Proagro 9001 (MH 2440)	Haryana	Suitable for rainfed *kharif* season, average grain yield 52 q/ha, dry fodder yield 150 q/ha, maturity 85-90 days, Fe: 45 ppm, Zn: 37 ppm,very compact cylindrical earhead, grey hexagonal seed. Tolerant to DM and blast, lodging and abiotic stresses.
Palem Sajja-1625 (PBH-1625) (MH 2323)	Telangana	Suitable for rainfed *kharif* season, average grain yield 32 q/ha, dry fodder yield 82 q/ha, late maturity (84 days). Rich in iron (78 ppm), zinc (59 ppm) and resistant to DM.
PCB 167 (GBL 5)	Punjab	Suitable for *kharif* timely sown irrigated condition, average grain yield 39.0 q/ha, dry fodder yield 227 q/ha, maturity 86 days (late), tolerant to major diseases, *viz* downy mildew, ergot, smut and insect pests of bajra.
BRBH-1 (BRBH 16620)	Karnataka Zone-3	Suitable for *kharif* timely sown irrigated condition, average grain yield 29.71 q/ha, dry fodder yield 60.19 q/ha, maturity 85 days, tolerant/ high degree of resistance to DM. Moderately resistant to blast, rust and ergot.
Super 99	Rajasthan	Suitable for irrigated and rainfed conditions, average grain yield 17.49 q/ha, maturity 84-86 days. Tolerant to DM, smut, ergot and blast.
Proagro 9001	Rajasthan	Suitable for *kharif* timely irrigated condition, average grain yield 27.08 q/ha, dry fodder yield 81 q/ha, maturity 87 days. Tolerant/high degree of resistance to DM, blast, rust and ergot.
Pusa 1801 (MH 2417)	National Capital Territory of Delhi	It is a dual-purpose hybrid suitable for *kharif* cultivation under irrigated and rainfed conditions, average grain yield 33.34 q/ha and dry fodder yield 175 q/ha, high iron (70 ppm) and zinc (57 ppm) content; resistant to all five important diseases of pearl millet, viz DM, foliar blast, rust, smut and ergot.
Little millet		
GPUL 11	Karnataka Zone 5 and 6	Suitable for *kharif* rainfed and irrigated condition, average grain yield 15-20 q/ha, fodder yield 300-350 q/ha, maturity 90-95 days (medium), resistance to grain smut and leaf blight, moderately resistant to shoot fly.
Konkon Satwik (DPLV-1) (LMV 548)	Rajasthan	Suitable for late sown/rainfed condition, average grain yield 19.24 q/ ha, maturity 118 days. Resistant to brown spot, leaf blast, shoot fly and aphids.
Proso millet		
CPRMV-1 (DHPM- 60-4/ PMV 466)	Karnataka and Tamil Nadu	Suitable for rainfed *kharif* season, average grain yield 24-26 q/ha, maturity 70-74 days, resistant to brown spot, leaf blast, leaf blight, moderately resistant to banded blight and tolerant to shootfly.
GPUP- 32	Karnataka Zone 5 and 6	Suitable for *kharif* rainfed and irrigated condition, average grain yield 18-20 q/ha, fodder yield 250-300 q/ha, maturity 80-85 days (medium), highly resistant to grain smut and brown spot disease.
Kodo millet		
CKMV 4 (ATL3) KMV558 (TNPsc313)	Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh and Tamil Nadu	Suitable for early and also late sowing in *kharif* and for sole as well as intercropping systems, average grain yield 30.18 q/ha, maturity 105-110 days (Short duration). Tolerant to head smut, banded blight, brown spot and leaf blight, drought tolerant.
CKMV 5 (ATL4) KMV568 (TNPsc308)	Andhra Pradesh, Chhattisgarh and Gujarat	Suitable for early and late *kharif*, average grain yield 32-35 q/ha, maturity 105-112 days. Moderately resistant to head smut, banded blight, brown spot, leaf blight, shoot fly, uniform maturity and non-lodging.
Finger millet		
VL Mandua 408 (CFMV 6) (FMV 1191)	Madhya Pradesh and Uttarakhand	Suitable for rainfed *kharif* ecology, average grain yield 30.33 q/ha, maturity 115 days. Moderately resistant to leaf, neck and finger blast, banded leaf blight and brown spot.
OUAT Kalinga Finger Millet-2 (Shreeprava) (7) (FMV 1198) (OEB 610)	Maharashtra, Chhattisgarh, Tamil Nadu and Odisha	Suitable for rainfed *kharif* season, average grain yield 26-27 q/ha, maturity 113 days. Resistant to leaf blast, brown spot, stem borer, grass hopper and aphids.
Palem Ragi –38 (PRS 38)	Telangana	Suitable for *kharif* sowing, average grain yield 20-25 q/ha, maturity 100-110 days. Moderately resistant to blast, tolerant to prolonged dry spells, higher Ca content (406 mg/100g).
ML-322	Karnataka (Zone 5)	Suitable for late *kharif* season in irrigated and rainfed areas, average grain yield 40 q/ha (irrigated), 25 q/ha (rainfed), fodder yield 55.0 q/ha, maturity 105-110 days. Tolerant to drought and lodging, resistant to neck blast.

Variety	Area of adoption	Salient features
Hagari Ragi-13 (HB-1)	Karnataka (Zone-2 and 3)	Suitable for late rainfed areas, average grain yield 23.56 q/ha, maturity 100-110 days, tolerant/moderately resistant to shoot fly.
VL Mandua 402	Uttarakhand	Suitable for rainfed situation, average seed yield 22.61 q/ha, maturity 111 days, higher calcium (368 mg/100g).
VL Mandua 409	Uttarakhand (Hills)	Suitable for rainfed organic *kharif* ecology, average grain yield 21.86 q/ha, maturity 116 days, high calcium (393 mg/100g), moderately resistant to neck and finger blast. Multi pest resistant variety and recorded very low incidence of *Myllocerus* weevil, stem borer, shoot aphids and grasshopper.
ATL 2 (TNEc -1294)	Tamil Nadu	Suitable for rainfed and irrigated condition, average grain yield 27.17 q/ha, maturity 115-120 days. Moderately resistant to all the three type of blasts, brown spot, grain mold and drought tolerant.
Foxtail millet		
CFXMV-1 (IIMR FxM-7) (FXV 645)	Andhra Pradesh and Karnataka	Suitable for rainfed *kharif* and irrigated summer season, average grain yield 25-28 q/ha, extra early maturity of 75-77 days, resistant to brown spot, rust, leaf blast, moderately resistant to banded blight, tolerant to shoot fly, high per day productivity.
AAU-GSG-Cawn 1 (Gossaigaon Cawn (Yellow Seeded) (GSCY 1)	Assam	Suitable for rainfed upland and low fertile lands, average grain yield 7-10 q/ha, maturity 115-120 days, high degree of resistance against blast.
PDKV Yashashree (BFTM 82)	Maharashtra	Suitable for rainfed condition, average grain yield 22.63 q/ha, maturity 81-85 days. Resistant to leaf blast, brown spot. Moderately resistant to rust and tolerant to shoot fly.
ATL 2 (TNSi -337)	Tamil Nadu	Suitable for rainfed condition, average grain yield 21.74 26.88 q/ha, medium duration 79-85 days, drought tolerant. Resistant to leaf blast, brown spot, rust and tolerant shoot fly.
Barnyard millet		
CBYMV-1 (BMV 611)	Andhra Pradesh, Karnataka, Madhya Pradesh, Tamil Nadu and Telangana	Suitable for rainfed *kharif* and irrigated *rabi* and summer, average grain yield 24-26 q/ha, maturity 90-94 days, moderately resistant to leaf blast, high per day productivity, high protein and Zn content.
VL Madira 254	Uttarakhand	Suitable for rainfed situations, average grain yield 17.19 q/ha, maturity 101 days.
Brown top millet		
GPUBT -2	Karnataka (Zone 5 and 6)	Suitable for *kharif* season, average grain yield 15-20 q/ha, fodder yield 200-250 q/ha, maturity 85-90 days (medium duration), resistant to leaf blight, moderately resistant to shoot fly.

Oilseeds: A total of 55 high-yielding varieties of oilseeds were released for different agro-ecological regions. These include 8 varieties of Indian Mustard, 2 of Yellow Sarson, 8 of Groundnut, 12 of Soybean, 9 of Linseed, 4 of Safflower, 5 of Sesame, 3 of Sunflower, 2 of Niger, and 2 of Castor.

List of improved released varieties/hybrids of Oilseeds

Variety	Area of adoption	Salient features
Indian mustard		
BPM 11 (Bharatpur Mustard 11) (DRMR 2018-19)	Rajasthan, Uttar Pradesh, Madhya Pradesh, Uttarakhand and Bihar	Suitable for late sown irrigated conditions, average seed yield 18.59 q/ha, maturity 123 days, oil content 37.8%. Resistant to white rust, *Alternaria* leaf blight, downy mildew, powdery mildew.
RH 1975	Jammu, Punjab, Haryana, Delhi and northern Rajasthan	Suitable for timely sown irrigated conditions in *rabi* season, average seed yield 27.20 q/ha, maturity 143 days. Tolerant to leaf blight, white rust and sclerotinia rot as compared to susceptible checks.
Pusa Double Zero Mustard 35 (PDZ 14)	Madhya Pradesh, Uttar Pradesh, Uttarakhand and Rajasthan	Suitable for timely sown irrigated condition, average seed yield 21.48 q/ha, maturity 132 days, mustard with Canola quality (erucic acid <2% and glucosinolates <30 ppm), yellow seeded variety. Resistant to white rust, *Alternaria* blight, *Sclerotinia* stem rot, downy and powdery mildew. Oil content 42.05%, oil yield 8.35 q/ha.
Pusa Double Zero Mustard 36 (PDZ 15)	Madhya Pradesh, Uttar Pradesh, Uttarakhand and Rajasthan	Suitable for timely sown irrigated condition, average seed yield 22.43 q/ha, maturity 132 days, mustard with Canola quality (erucic acid <2% and glucosinolates <30 ppm), yellow seeded variety with 0.45% erucic acid in oil and 19.50 ppm glucosinolates in the seed meal. Resistant to powdery mildew, white rust. Tolerant to water stress, oil content 42.15%, oil yield 8.56 q/ha.
Gujarat Mustard 7 (Banas Anmol) (SKM 1746)	Gujarat	Suitable for irrigated condition, average seed yield 26.47 q/ha, maturity 105 days, dwarf and bold seeded, oil content 39.4%.

Variety	Area of adoption	Salient features
TJM 1 (Trombay Jodhpur Mustard 1)	Rajasthan	Suitable for irrigated condition, average seed yield 23.33 q/ha, maturity 117-124 days. Moderately resistant to white rust, highly resistant to powdery mildew.
TJM 2 (Trombay Jodhpur Mustard 2)	Rajasthan	Suitable for irrigated, timely sown condition, average seed yield 18.31 q/ha, maturity 118-128 days. Moderately resistant to white rust, resistant to powdery mildew.
PA 5210 (5 I J 1110)	Rajasthan	Suitable for irrigated mid-late conditions, average seed yield 23-30 q/ha, maturity 130-135 days, high level of tolerance against white rust.
Yellow sarson		
JYS 2 (RMYS 2) (Jodhpur Yellow Sarson 2)	Rajasthan	Suitable for timely sown irrigated/rainfed condition, average seed yield 21.20 q/ha, maturity 114-121 days. Resistant to white rust, downy mildew
JYS 1 (RMYS 1) (Jodhpur Yellow Sarson 1)	Rajasthan	Suitable for timely sown irrigated condition, average seed yield 21.47 q/ha, maturity 116-125 days. Moderately resistant to white rust, powdery mildew
Groundnut		
VRI 11 (VG 19721)	Gujarat and Rajasthan	Suitable for irrigated rainfed cultivation during *kharif* season, average pod yield 32.13 q/ha, maturity 105-110 days. Moderately resistant to early leaf spot, rust, *Alternaria* blight, stem rot, dry root rot, sucking pests and defoliators.
VRI 12 (VG 19535)	Uttar Pradesh, Haryana, Rajasthan and Punjab (Zone I)	Suitable for irrigated rainfed cultivation during *kharif* season, average pod yield 38.17 q/ha, maturity 115-120 days. Moderately resistant to early leaf spot, *Alternaria* leaf blight, collar rot, stem rot, dry root rot. Less incidence of leaf hoppers, thrips, *Spodoptera* and leaf miner.
Gujarat Groundnut 39 (Sorath Uttam)	Gujarat	Suitable for *kharif* groundnut growing areas of the Gujarat state, average pod yield of 26.19 q/ha, maturity 113 days. Tolerant to tikka, rust. Lower incidences of stem rot, collar rot, leaf defoliators infestation. Biofortified variety with FAD2 gene introgressed using MAS for high oleic acid content.
Himani (TCGS 1522)	Andhra Pradesh	Suitable for *kharif* and *rabi* season, average pod yield of 22-25 q/ha, maturity 100-105 days, tolerant to late leaf spot (LLS) and rust, oil content 48.5%.
Girnar 6 (NRCGCS 637)	Rajasthan, Uttar Pradesh, Punjab states and Haryana) of India	Suitable for timely sown *kharif* season, average pod yield 30.30 q/ha, maturity 123 days, oil content 51%, protein content 28%. Moderately tolerant to early and late seasons drought. Moderately resistant to early leaf spot, rust, *Alternaria* blight, collar rot, stem rot, dry root rot. Less incidence of leaf hoppers, thrips, *Spodoptera.*
TCGS 1707 (ICAR KONARK) Spanish Bunch	Odisha and West Bengal	Suitable for timely sown rainfed/irrigated *kharif*, average pod yield 24.76 q/ha, maturity 110-115 days, oil content 49%, protein content 29%. Moderately resistant to foliar diseases (LLS and Rust), soil borne diseases (collar rot, stem rot and dry root rot), sucking pests (leaf hoppers and thrips).
Chhattisgarh Trombay Mungfali	Chhattisgarh	Suitable for timely sown *kharif* and summer, average pod yield 34.05 q/ha (*kharif*), 47.75 q/ha (summer), maturity 106 days, oil content 49%. Moderately resistant to early leaf spot (ELS) and peanut bud necrosis. Moderately susceptible to late leaf spot (LLS), rust, tolerant to field insect pests.
Groundnut CO 8 (COG 0537)	Tamil Nadu	Suitable for timely sown *kharif* (rainfed with supplemental irrigation) and *rabi* (irrigated), average pod yield 25.27 q/ha *(kharif)*, 23.43 q/ha *(rabi)*, maturity 110-115 days, oil content 51-52%. Moderately resistant to late leaf spot, early leaf spot, rust. Moderately resistant to sucking pest (leaf hoppers), resistant to leaf miner.
Soybean		
Pant Soybean 27 (PS 1670)	Punjab, Uttar Pradesh (except Bundelkhand region and Delhi	Suitable for normal to late sown conditions, average seed yield 23-24 q/ha, maturity duration 116-126 days. Resistant to yellow mosaic virus, bacterial pustules and bacterial leaf blight, soybean mosaic virus. Moderately resistant to *Rhizoctonia* aerial blight.
JS 22-12 (Jawahar Soybean 22-12)	Madhya Pradesh, Vidarbha and Marathwada regions of Maharashtra, Rajasthan, Gujarat and Bundelkhand region of Uttar Pradesh	Suitable for *kharif* season under normal sown conditions, average seed of 21.21 q/ha, early maturity 90.5 days, resistant to lodging, shattering and having good germinability.
JS 22-16 (Jawahar Soybean 22-16)	Madhya Pradesh, Vidarbha and Marathwada regions of Maharashtra, Rajasthan, Gujarat and Bundelkhund region of Uttar Pradesh	Suitable for *kharif* season under normal sown conditions, average seed yield 19-22 q/ha, early maturity 90-93 days. Highly resistant to charcoal rot, yellow mosaic virus, *Rhizoctonia* aerial blight, anthracnose, stem fly, girdle beetle and defoliators.

Variety	Area of adoption	Salient features
NRC 165	Madhya Pradesh, Vidharbha and Marathwada region of Maharashtra, Bundelkhund region of Uttar Pradesh, Rajasthan and Gujarat	Suitable for timely sown rainfed conditions of Central zone, average seed yield 16-20 q/ha, maturity 87-92 days, oil content 19.45%, tolerant to pod shattering, moderately resistant to target leaf spot and highly resistant to *Alternaria* leaf spot.
NRC 181	Madhya Pradesh, Rajasthan, Gujarat, Marathwada and Vidarbha region of Maharashtra, Bundhelkhand region of Uttar Pradesh	Suitable for *kharif* season under normal sown conditions, average seed yield 17.21 q/ha, early maturity 92 days, oil content 20.47%, protein content 41% (on dry weight basis), KTI free variety developed by using MAS with null KTI allele. Resistant to yellow mosaic virus, moderately resistant to yellow mosaic virus, resistant to defoliators. Moderately resistant to girdle beetle and stem fly.
NRC 188	Madhya Pradesh, Rajasthan, Gujarat, Marathwada and Vidarbha region of Maharashtra, Bundhelkhand region of Uttar Pradesh	Suitable for *kharif* season under normal sown conditions, vegetable soybean variety, green pod yield 44-47 q/ha, seed yield 17.6 q/ha, maturity in 76.8 days to green pod picking, glabrous pod, high green seed weight, tolerant to pod shattering, oil content 21.22% in mature seeds, protein content 36.0% (on dry weight basis) at picking stage, resistant to pests semilooper and moderately resistant to *S. litura.*
Gujarat Soybean 4 (G. Soy 4: Sorath Sonali)	Gujarat	Suitable for rainfed condition of Gujarat state and amenable to mechanical harvesting, average seed yield 21.60 q/ha, maturity 104 days, 19.52% oil content and 36.78% protein content.
NRC 197	Himachal Pradesh and Uttarakhand	Suitable for rainfed *kharif* season, average seed yield 16.24 q/ha, maturity 112.67 days, non-shattering, tolerant to lodging. Resistant to insect-pest complex, stem fly. Highly resistant to semilooper, moderately resistant to *Spodoptera litura.*
NRC 149	Punjab, Haryana, Delhi, North Eastern Plains of Uttar Pradesh, Plains of Uttarakhand and Eastern Bihar	Suitable for rainfed *kharif* season, average seed yield 24.0 q/ha, maturity 127 days, non-shattering, non-lodging, highly resistant to stem fly, defoliators, white fly, YMV, pod blight, *Rhizoctonia* aerial blight.
MAUS 731	Marathwada region of Maharashtra	Suitable for timely sown rainfed condition, average seed yield 23.22 q/ha, maturity 97 days, oil content 20.5%, protein 40.5%, moderately resistant to charcoal rot.
DS 9421 (Pusa Soybean 21)	Jammu and Kashmir	Suitable for Kashmir valley, average seed yield 20.27 q/ha, maturity 120-125 days. Highly resistant to aphids, white fly, leaf webber, resistant to stem fly, gridle-beetle. Moderately resistant to pod borer.
SKAU-S-3 (Shalimar Soybean-3)	NCT Delhi	Suitable for irrigated condition, average seed yield 12.29 q/ha, maturity 110-117 days. Resistant to yellow mosaic virus, soybean mosaic virus, bud blight. Moderately resistant to stem fly.
Linseed		
SHA-5 (SHUATS Alsi-5)	Uttar Pradesh (Excluding Budelkhand), Bihar, Jharkhand, West Bengal, Assam	Suitable for irrigated condition, average seed yield 13.38 q/ha, maturity 126 days. resistant to rust, powdery mildew, bud fly.
BUAT Alsi-5 (LMS 2017-I-12)	Himachal Pradesh, Punjab and Jammu	Suitable for irrigated condition, average seed yield 14.05 q/ha, maturity 152 days, highly resistant to rust, moderately resistant to budfly.
LCK 1021 (Anu)	Uttar Pradesh	Suitable for rainfed condition, average seed yield 7.85 q/ha, maturity 131 days, resistant to *Alternaria* blight, powdery mildew, moderately resistant to wilt.
DLV-7 (Wish-Win)	Karnataka Zone- 3	Suitable for rainfed condition, average seed yield 8.26 q/ha, maturity 109 days. Moderately resistant to wilt, powdery mildew and bud fly.
RMLS-11 (Raichur Malghatti local selection)	Karnataka Zone- 2 and 3	Suitable for rainfed condition, average seed yield 9.86 q/ha, maturity 105-108 days, resistant to powdery mildew and moderately resistant to *Alternaria* blight.
RL 18106 (Kota Barani Alsi 7)	Rajasthan	Suitable for rainfed condition, average seed yield 15.0 q/ha, maturity 116-120 days. Moderately resistant to *Alternaria* blight, wilt diseases and bud fly.
Jawahar Linseed Sagar 121 (JLS 121)	Madhya Pradesh	Suitable for timely sown rainfed situation, average seed yield 8.40 q/ha, maturity 115-117 days, resistant to rust. Moderately resistant to powdery mildew, wilt, *Alternaria* blight and bud fly.
Jawahar Linseed Sagar 133 (Jls 133)	Madhya Pradesh	Suitable for rainfed condition, average seed yield 11.4 q/ha, maturity 110-115 days, moderately resistant to rust, bud fly.
BUAT Alsi-3 (LMS -2012-42)	Uttar Pradesh	Suitable for rainfed, average seed yield 10.33 q/ha, maturity 127 days. Resistant to rust and moderately resistant to *Alternaria* and bud fly.
Safflower		
Chhattisgarh Kusum-2	Chhattisgarh	Suitable for rice based late sown irrigated condition, average grain yield 20.17 q/ha, maturity 135 days, oil content 35%, escape aphid infestation under late sown condition of Chhattisgarh.

Variety	Area of adoption	Salient features
ISF-300	Maharashtra, Karnataka, Andhra Pradesh, Telangana, Madhya Pradesh, Chhattisgarh	Suitable for timely sown rainfed/irrigated condition, average seed yield 17.96 q/ha, maturity 134 days, oil content 38.2%, resistant to *Fusarium* wilt.
ISF-123-sel-15	Karnataka, Maharashtra, Andhra Pradesh, and Telangana	Suitable for late sown rainfed condition, average seed yield 16.31 q/ha, maturity 127 days, oil content high (34.3%), resistant to *Fusarium* wilt, moderately tolerant to highly susceptible to aphid infestations.
Phule Bhumi (SSF-18-02)	Zone I: Maharashtra, Karnataka, Andhra Pradesh, and Telangana Zone II: Madhya Pradesh and Chhattisgarh	Suitable for late sown rainfed/irrigated condition, average seed yield 18.44 q/ha (irrigation), maturity 136 days, oil content 33.7%, less hull content (46.5%), moderately resistant to *Fusarium* wilt.
Sesame		
Sabour Til- 1 (BRT-04)	Bihar, Andhra Pradesh, West Bengal and Madhya Pradesh	Suitable for irrigated condition during *rabi*/summer, average seed yield 9.9 q/ha, maturity 84-90 days. Moderately resistant to *Macrophomina* stem rot, root rot, *Alternaria* leaf spot, *Cercospora* leaf spot, phyllody, heat tolerant. The variety is tolerant to heat, can be grown during summer season.
Tilhan Tec Til-1 (IIOS-1101)	Karnataka, Maharashtra, Telangana, Odisha, West Bengal and Tamil Nadu	Suitable for irrigated condition during *rabi* and also in summer, average seed yield 9.6 q/ha, maturity 90 days. Moderately resistant to *Macrophomina* root and stem rot, *Alternaria* and *Cercospora* leaf spots, leaf webber and capsule borer, leaf hopper, tolerant to heat.
Tanjila (CUMS-09A)	West Bengal, Bihar, Odisha, Maharashtra, Chhattisgarh, Telangana, Karnataka, Tamil Nadu and Kerala	Suitable for irrigated, summer crop with early or late sown condition, average seed yield 9.63 q/ha - 11.48 q/ha, oil yield 4.39 q/ha – 5.58 q/ha, oil content 46.17%, maturity 91 days. Highly resistant to root rot, phyllody, powdery mildew.
TLT- 10 (Trombay Latur Til)	Maharashtra	Suitable for cultivation during *kharif* (rainfed) and *rabi* summer (irrigated) season, average seed yield 6.61 q/ha (*kharif*) and 7.67 q/ha (*rabi*), maturity 92 days. Moderately resistant to leaf webber, capsule borer, root and stem rot, phyllody.
Bharani (GKVKS- 1)	Karnataka Zone- 5	Suitable for early *kharif* and late sowing, average seed yield 4.5-5.0 q/ha, maturity 75-85 days, more filled capsules per plant, higher source: sink proportion. Moderately resistant to *Macrophomina* root and stem rot, phyllody, leaf webber, capsule borer.
Niger		
JNS 2017-13	Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Odisha, Karnataka, Andhra Pradesh and Jharkhand	Suitable for rainfed and irrigated condition, average seed yield 5.5-6.0 q/ha, maturity 94-100 days, moderately resistant to *Cercospora*, *Alternaria* leaf spot, powdery mildew, white fly, leaf hopper.
KBN -2	Karnataka Zone- 5 and 6	Suitable for rainfed *kharif* season, average seed yield 5.55 q/ha, maturity 80-85 days (short duration). Resistant to *Macrophomina* root and stem rot, powdery mildew, *Alternaria* and *Cercospora* leaf spots.
Sunflower		
Tilhan Tec-SUNH-2 IIOSH-460	Uttarakhand, Jammu and Kashmir, Gujarat, Maharashtra, Northern Karnataka, Andhra Pradesh, Southern Karnataka, Tamil Nadu and Telangana and All India	Suitable for rainfed/timely sown condition, average grain yield 15.70 q/ha, maturity 90-100 days, resistant to downy mildew, moderately resistant to leaf hopper.
KBSH-88	Uttarakhand, Jammu and Kashmir, Gujarat, Maharashtra, Northern Karnataka, Andhra Pradesh, Southern Karnataka, Tamil Nadu and Telangana	Suitable for rainfed/timely sown condition, average seed yield 15.59 q/ha, maturity 86-88 days, resistant to downy mildew, moderately tolerant to powdery mildew.
PDKV Suraj (PDKVSH 964)	Maharashtra	Suitable for rainfed *kharif* season, average seed **y**ield 18-22 q/ha, maturity 89-90 days. Moderately resistant to *Alternaria* disease, leaf hopper.
Castor		
Tilhan Tec ICH-6 (ICH-1146)	All castor growing states in India under rainfed and irrigated conditions Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Odisha, Gujarat, Rajasthan and Haryana	Suitable for high-density planting, average seed yield 15.16 q/ha, maturity 90-121 days, moderately resistant to leafhopper and thrips under field conditions using infester row technique.
RHC-2 (Rajasthan Hybrid Castor-2)	Rajasthan	Suitable for irrigated, timely sown condition, average seed yield 33.78 q/ha, maturity 55-60 days, resistant to root rot and moderately resistant to wilt.

Pulses: A total of 69 high-yielding varieties of pulses have been released for different agro-ecological regions. These include 19 varieties of chickpea, 4 of pigeon pea, 7 of lentil, 6 each of field pea and urdbean, 15 of mung bean, 3 of cowpea, 2 each of lathyrus and mothbean, and 1 each of rajmash, cluster bean, horsegram, faba bean, and Indian bean.

List of released varieties/hybrids of Pulses

Variety	Area of adoption	Salient features
Chickpea		
GJG 1913 (Gujarat Gram 8)	NEPZ of India (Assam, West Bengal, Jharkhand, Bihar, Eastern Uttar Pradesh, Manipur), SZ of India (Karnataka, Andhra Pradesh, Tamil Nadu)	Suitable for salt affected (ECe-5.1-6.7 dS/m) soils, also recommended for mechanical harvesting as it is lodging resistance and erect type, desi chickpea variety, average seed yield 21.16 q/ha, maturity 93 days. Moderately resistant to wilt, dry root rot, stunt and collar rot diseases. Better tolerance against *Helicoverpa armigera*.
Gujarat Kabuli Gram 2 (Sorath Kabuli 2)	Gujarat	Suitable for irrigated condition, average seed yield 21.17 q/ha, maturity 115-120 days, resistant to wilt and stunt diseases.
Saatvik (NC 9) [IC 650347]	Gujarat, Maharashtra, Madhya Pradesh, Southern Rajasthan and Bundelkhand region of Uttar Pradesh	Suitable for *rabi*, timely sown rainfed conditions, average yield 16.86 q/ha, maturity 105 days, MAS derived drought tolerant variety, introgression line harbouring major QTL CaqDYI(P/H)1.1 (CabHLH10) gene, resistant to Fusarium wilt, stunt, moderately resistant to dry root rot.
IPCB 2015-132 (Kundan)	North East Plain Zone (Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam)	Suitable for mechanical harvesting, irrigated timely sown condition, average seed yield 17-18 q/ha, maturity 126-130 days, 100 seed wt. 14.7 g, resistant to *Fusarium* wilt.
DBGC 3 (Swarna Lakshami IC650181)	North East Plain Zone (Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam)	Suitable for timely sown irrigated condition, average seed yield of 17-18 q/ha, maturity 125-130 days, moderately resistant to *Fusarium* wilt, double flower/peduncle, 100 seed wt. 21.3 g.
RKGM 20-1 (Kota Desi Chana 2)	South Zone (Andhra Pradesh, Telangana, Karnataka)	Suitable for timely sown, irrigated conditions, average seed yield 20.72 q/ha, maturity 95 days, moderately resistant to wilt, dry root rot, collar rot and stunt, lesser incidence of pod borer, medium bold seed (24.7 g/100 seed).
RKGM 20-2 (Kota Desi Chana 3)	North Eastern Plain Zone (Assam, Bihar, Jharkhand, West Bengal)	Suitable for timely sown, irrigated conditions, average seed yield 15.57 q/ha, maturity 128 days. Moderately resistant to wilt, dry root rot, collar rot and stunt, lesser incidence of pod borer.
Pusa Chickpea 3057	Delhi	Suitable for timely sown rainfed/ 1-2 irrigations condition, average seed yield 20.1 q/ha, maturity 135 days. Resistant to *Fusarium* wilt, collar rot. Moderately resistant to dry root rot, *Ascochyta* blight, botrytis gray mold, high seed protein content (24.3 %), 100-seed weight 30-35 g, drought resistant.
Raj Vijay Kabuli Gram 2021 (RVKG 2021) (RVSSG 62)	Madhya Pradesh	Suitable for timely sown irrigated conditions, average seed yield 18-20 q/ha, maturity 110-115 days, moderately resistant to *Fusarium* wilt, 100 seed wt. is 36.7 g.
Raj Vijay Gram 2K21 (RVG 2K21) (RVSSG 61)	Madhya Pradesh	Suitable for timely sown irrigated conditions, average seed yield 17-20 q/ha, maturity 111 days, moderately resistant to *Fusarium* wilt, large seed (42.2 g/100 seeds).
Nandyal Gram 924 (NBeG 924)	East Central Zone (Madhya Pradesh, Chhattisgarh and parts of Odisha)	Suitable for rainfed condition, could also be grown with 2-3 protective irrigations, *desi* variety, average seed yield 17.22 q/ha, early maturity (105-115 days), resistant/moderately resistant to *Fusarium* wilt.
Nandyal Gram 1267 (NBeG 1267)	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for mechanical harvesting in rainfed during *rabi*, *desi* variety, could also be grown with 1-2 protected irrigations in normal fertility condition, average seed yield 20.95 q/ha, maturity early (90-95 days) and seed protein 15.96%.
Pant Gram 10 (PG 265)	Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for *desi* timely sown rainfed/irrigated conditions of *rabi* season, average seed yield 17.79 q/ha, maturity 130 days. Moderately resistant to wilt, collar rot, stunt. Tolerant to pod borer.
KCD-11 (KCD 2019-05)	Karnataka (Zone- 1, 2 and 3)	Suitable for all chickpea growing areas of zone 1, 2 and 3 of Karnataka in rainfed/ irrigated condition, average seed yield 17-18 q/ha, maturity 95 days, 100-seed weight 21-22 g, tolerant to wilt and drought.
PBG-10	Punjab	Suitable for timely sown, irrigated conditions, average seed yield 24.8 q/ha, maturity 153 days, 100-seed wt. 25.9 g. Moderately resistant to *Ascochyta* blight, Botrytis grey mold (BGM).
Kota Desi Chana 4 (RKG 13-380)	Rajasthan	Suitable for timely sown, irrigated conditions, average seed yield 30.8 q/ha, maturity 118 days. Moderately resistant to wilt, dry root rot, lesser incidence of pod borer.

Variety	Area of adoption	Salient features
Kota Desi Chana 5 (RKG 13-515-1)	Rajasthan	Suitable for late sown irrigated conditions, average seed yield 29.0 q/ha, maturity 122 days, 100 seed wt: 23.06 g, resistant/moderately resistant to wilt, dry root rot, collar rot, BGM and stunt, lesser incidence of pod borer.
Kota Desi Chana 6 (RKG 19-1)	Rajasthan	Suitable for timely sown, irrigated conditions, average seed yield 22.16 q/ha, maturity 111 days. Moderately resistant to wilt, dry root rot and collar rot, lesser incidence of pod borer.
Parbhani Chana- 16 (BDNG 2018-16)	Maharashtra	Suitable for timely sown irrigated conditions, average seed yield 27.9 q/ha, maturity 110-115 days, 100-seed weight 30 g, resistant to *Fusarium* wilt.
Pigeon pea/Red gram		
Gujarat Tur 109 (GT 109: Shweta) (AAUVT 17-02)	Gujarat	Suitable for *kharif* season, average seed yield 19.18 q/ha, maturity 161-176 days, higher protein content (23.35%), nutrients like Fe (32.54 mg/kg) and Zn (22.38 mg/kg). Resistance to wilt and SMD.
Pusa Arhar Hybrid 5	Delhi	Suitable for *kharif*, average seed yield 23.24 q/ha, maturity 163 – 170 days. Moderately resistant to sterility mosaic disease, *Phytophthora* blight, low incidence of *Macrophomina* blight, *Alternaria* leaf spot.
Phule Pallavi (Phule Tur-12-19-2)	Maharashtra, Gujarat, Madhya Pradesh and Chhattisgarh during *kharif*	Suitable for normal sown rainfed/irrigated areas in *kharif* season, average seed yield 21.45 q/ha, maturity mid-early 157-159 days. Moderately resistant to wilt and sterility mosaic disease.
NAAM-88	Karnataka, Telangana, Andhra Pradesh, Tamil Nadu	Suitable for rainfed/irrigated areas in *kharif* season, average seed yield 14.90 q/ha, maturity early (142 days). Moderately resistant to wilt.
Cowpea (Grain)		
GC 1601	All Zones of India	Suitable for irrigated condition, average seed yield 11.84 q/ha, maturity 73.6 days. Moderate to high resistance to CYMV, free from dry root rot, resistant to lodging and shattering.
Pant Lobia-8 (PGCP-67) (Pant Grain Cowpea -67)	Uttarakhand	Suitable for spring-summer and *kharif* season, average seed yield 12.06 q/ha, maturity 65-70 days, moderately resistant to aphids and thrips.
SKAU-C-407 Shalimar Cowpea-3	Jammu and Kashmir	Suitable for Kashmir Valley up to an altitude of 1,850 msl in rainfed, high fertility *kharif* sowing, average grain yield 8.02 q/ha, maturity 92-95 days, protein content 29.32%, seed is rich in Zn and Fe (29.88 ppm and 105.2 ppm respectively), crude protein 13.12%, crude fibre 18.99%, tolerant to drought stress in Kashmir valley. Highly resistant to *Cercospora* leaf spot, cowpea mosaic virus. Moderately resistant to pod borer.
Rajmash		
SKAU-R-91 Shalimar Rajmash-5	Jammu and Kashmir	Suitable for Kashmir Valley up to an altitude of 2,200 msl in irrigated, high fertility *kharif* season, maturity early 90-95 days, average seed yield 16.16 q/ha, highly resistant to Angular leaf spot and wilt, moderately resistant to pod borer.
Cluster bean (Guar)		
Karan Gaur-15 (RGr-20-15)	Rajasthan, Gujarat, Haryana and Maharashtra	Suitable for both irrigated and rainfed conditions, average seed yield 13.37 q/ha, maturity 99-104 days. Moderately resistant to bacterial blight, root rot and *Alternaria* leaf blight.
Horse gram		
Phule Viraj (GRB-701)	Western Maharashtra	Suitable for *kharif* season, average seed yield 15.92 q/ha, maturity 80-82 days, moderately resistant to *Fusarium* wilt and BCMV.
Lentil		
LH 17-19	Punjab, Haryana, Delhi, western Uttar Pradesh, Rajasthan, plains of Uttarakhand and Jammu region	Suitable for irrigated areas during *rabi*, average seed yield 13.65 q/ha, maturity 130-135 days, small seeded (2.4 g/100 seeds) with small black spots, resistant to rust and moderately resistant to wilt.
LL 1655	Punjab, Haryana, Delhi, western Uttar Pradesh, Rajasthan, plains of Uttarakhand and Jammu region	Suitable for irrigated *rabi* condition, average seed yield 14-15 q/ha, maturity 140-145 days, 100 seed wt. 2.0 g, moderately resistant to rust and tolerant to wilt.
Pusa Shweta PSL -19	Delhi	Suitable for salt affected (ECe-5.1-6.7 dS/m) soils, average seed yield 10.89 q/ha, maturity 124 days, tolerant to medium saline conditions, moderately tolerant to wilt and rust.
Pant Lentil 14 (PL 320)	Punjab, Haryana, Delhi, North-West and Central Rajasthan, Western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for timely sown rainfed/irrigated conditions of *rabi* season, average seed yield 15.55 q/ha, maturity 128 days, high seed protein content (25.72%). Resistant to rust, *Stemphylium* blight. Moderately resistant to wilt, *Ascochyta* blight, sod borer, aphid.

Variety	Area of adoption	Salient features
Pant Lentil 15 (PL 342)	Punjab, Haryana, Delhi, North-West and Central Rajasthan, Western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for timely sown rainfed/irrigated conditions of *rabi* season, average seed yield 15.59 q/ha, maturity 127 days, high seed protein content (26.24%). Moderately resistant to rust, wilt. Resistant to ascochyta blight, *Stemphylium* blight. Moderately resistant to pod borer, aphid.
RKL 20-26 (D) Kota Masoor 6	North Western Plain Zone and Central Zone of India	Suitable for rainfed normal sown conditions in *rabi* season, yield 17.37 q/ha (NWPZ), 16.0 q/ha (CZ), maturity 125 days (NWPZ), 111 days (CZ), protein (21.07 %), moderately resistant to rust and wilt.
PSL-17	National Capital Territory of Delhi	Suitable for salinity conditions, average seed yield 12.95 q/ha, maturity 125 days. Rich in iron (67.0 ppm), zinc (41 ppm) and protein (28.8%). Moderately resistant to wilt and rust.
Field pea		
Anindya WBFP 14-S9 [IC 639990]	West Bengal	Suitable for irrigated condition, maturity 113-126 days, average seed yield 16-18 q/ha. Resistant to powdery mildew, *Ascochyta* blight and rust.
Pant Pea 484	Punjab, Haryana, Delhi, North-West and Central Rajasthan, Western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for timely sown rainfed/irrigated conditions of *rabi* season, average seed yield 23.33 q/ha, maturity 120 days, protein content 26.17%, resistant to *Ascochyta* blight. Moderately resistant to rust, powdery mildew, aphid and pod borer.
Pant Pea 497	Punjab, Haryana, Delhi, North-West and Central Rajasthan, Western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for *rabi* season, average seed yield 19.7 q/ha, seed protein 25.05%, maturity 123 days, resistant to *Ascochyta* blight. Moderately resistant to rust and powdery mildew, aphid, pod borer.
Pant Pea 498	Punjab, Haryana, Delhi, North-West and Central Rajasthan, Western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for *rabi* season, average yield 20.5 q/ha, seed protein 22.51%, maturity 123 days. Resistant to *Ascochyta* blight. Moderately resistant to rust, powdery mildew.
Pant Pea 501	Punjab, Haryana, Delhi, North-West and Central Rajasthan, Western Uttar Pradesh, Plains of Uttarakhand and Jammu and Kashmir	Suitable for *rabi* season, average seed yield 21.4 q/ha, seed protein 22.70%, maturity 123 days. Moderately resistant to aphid and pod borer.
SKAU-P-17 Shalimar Pea-2	Jammu and Kashmir	Suitable for rainfed plain areas for elevation up to plain to mid hill up to 1,800 m asl, average seed yield 13 q/ha, maturity 202-205 days, resistant to jassid and leaf minor. Moderately resistant to pod borer, aphids, powdery mildew.
Greengram/Mungbean		
ML 2015 (SML 2015)	Chhattisgarh, Uttar Pradesh, Odisha, Bihar, Assam, West Bengal and Jharkhand	Suitable for irrigated conditions, average grain yield 11.18 q/ha, maturity 64-88 days, moderately resistant to mungbean yellow mosaic virus (MVMV) disease and tolerant to other foliar diseases, grains are medium sized and shiny green.
ML 1839 (SML 1839)	NEPZ (Chhattisgarh, Uttar Pradesh, Odisha, Bihar, Assam, West Bengal and Jharkhand)	Suitable for irrigated conditions, average grain yield 10.58 q/ha, maturity 62-87 days, moderately resistant to MYMV. Tolerant to other foliar diseases, grains are medium sized and shiny green.
Lam Pesara LGG 600	Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Telangana and Odisha states	Suitable for rice fallows and upland situations during *rabi* season, average seed yield 11.40 q/ha, maturity 70-75 days, resistant to MYMV.
Lam Pesara LGG 630	Andhra Pradesh	Suitable for all seasons, both in upland and rice fallows, average grain yield 12-14 q/ha, maturity 65-70 days, resistant to MYMV.
MH 1762	Punjab, Haryana, Delhi, western Uttar Pradesh, Rajasthan and plains of Uttarakhand and Jammu region	Suitable for irrigated condition, average grain yield 14.45 q/ha, maturity 61-62 days, moderately resistant to ULCV and root rot, highly resistant to MYMV, resistant to anthracnose.
MH 1772	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for cultivation during *kharif* season, average grain yield 13.68 q/ha, maturity 67 days. Moderately resistant to *Cercospora* leaf spot, *Anthracnose*, root rot, bacterial leaf spot and *Macrophomina* blight.
Gujarat Mung 9 (GM 9) (SKNM1705)	Gujarat	Suitable for *kharif*, average grain yield 9.98 q/ha, maturity 68 days, resistant to MYMV.
Gujarat Mung 10 (Sorath Moti) (GJM 1701)	Gujarat	Suitable for *kharif* season cultivation, average grain yield 10.36 q/ha, maturity 65 days. Resistant to MYMV, anthracnose, leaf curl and powdery mildew.
Lam Pesara 610 (LGG 610)	Andhra Pradesh, Telangana, Tamilnadu, Karnataka, Kerala and Odisha	Suitable for rice fallows and upland situations during *rabi* season. amenable to mechanical harvesting, average grain yield 11.17 q/ha, maturity 74 days, protein (23.16%), resistant to MYMV.

Variety	Area of adoption	Salient features
PMS-8	NCR of Delhi	Suitable for moderate salt-affected soil during summer season, average grain yield 4.95 q/ha, maturity 70 days, protein content 23.5%. Resistant to MYMV, web blight, cercospora leaf spots, bacterial leaf blight, *Anthracnose*, powdery mildew, macrophomina, urdbean leaf curl virus, leaf curl virus and root rot, whitefly, maruca, pod borer.
PMD-9	National Capital Region of Delhi	Suitable for cultivation during summer irrigated conditions, average grain yield 10.76 q/ha, maturity 61 days (early), protein 25.5%, good cooking quality. Resistant to MYMV, *Cercospora* leaf spots, *Anthracnose*, web blight, urdbean leaf crinkle virus. Tolerant to thrips, white fly, pod borer, pod bug, maruca, heat and drought tolerant.
PMD-10	National Capital Region of Delhi	Suitable for cultivation during summer irrigated conditions, average grain yield 11.13 q/ha, maturity 60 days (early), protein 24.5%, good cooking quality. Resistant to MYMV, *Cercospora* leaf spots (CLS), *Anthracnose*, web blight, urdbean leaf crinkle virus, tolerant to thrips, white fly, pod borer, pod bug and maruca, heat and drought tolerant.
VBN- 7 (VGG- 18-002)	Tamil Nadu	Suitable for summer cultivation in both irrigated and rainfed conditions, average grain yield 10.36 q/ha, maturity 65-70 days, moderately resistant to MYMV, powdery mildew. Resistant to Urdbean Leaf Crinkle Virus, contains high vitamin C (18.17 mg/100g) in the sprouted grains and 23.13% protein.
Ankush (WBM 031)	West Bengal	Suitable for spring - summer cultivation during post *kharif* season, average grain yield 11.55 q/ ha, maturity 62-69 days. Highly resistant to powdery mildew, resistant to MYMV, moderately resistant to web blight.
Phule Suvarn Phule M-0702-1	Maharashtra	Suitable for *kharif* late sown cultivation, average grain yield 18.70 q/ha, maturity 62-74 days, medium bold seeded, moderately resistant to powdery mildew, MYMV.
Urdbean/blackgram		
KPU 18-1 (Kota Urd 6)	Punjab, Haryana, Uttarakhand, Rajasthan and part of Himachal Pradesh	Suitable for early and late sown conditions, average grain yield 14.06 q/ha, maturity 76 days. Moderately resistance to MYMV, *Cercospora* leaf spot, leaf curl virus and powdery mildew.
Mash 878 KUG 878	North West Plain Zone (NWPZ)	Suitable for irrigated conditions, average grain yield 14.62 q/ha, maturity 74-82 days, resistant to MYMV. Tolerant to web blight, *Anthracnose* and bacterial leaf spot.
Lam Minumu 904 LBG 904	Andhra Pradesh	Suitable for all seasons, average grain yield 12-14 q/ha, maturity 85-90 days, resistant to MYMV, tolerant to leaf curl virus.
AAU SHL Urd 03 (SB 42-8)	Assam	Suitable for *kharif*, average grain yield 12-14 q/ha, maturity 60-68 days. Resistant to MYMV, *Cercospora* leaf spot.
TBG 129 (Tirupati Minumu 2)	Andhra Pradesh	Suitable for *kharif*, *rabi*, summer and rice fallow situations, average grain yield 16-18 q/ha, maturity 85-90 days, resistant to MYMV.
Phule Rajan (PU-0819-18)	Maharashtra	Suitable for *kharif* cultivation, average grain yield 18.30 q/ha, maturity 72-81 days, moderately resistant to powdery mildew and MYMV.
Lathyrus		
Hazari (WBK 1401-3)	West Bengal	Suitable for irrigated condition, average seed yield 18.21 q/ha, maturity 114-124 days, resistant to wilt and rust, ODAP content – 0.16%.
Nilima (WBK1402-7)	West Bengal	Suitable for rainfed *rabi* condition, average seed yield 18.5 q/ha, maturity 124 days, resistant to wilt and rust, ODAP content – 0.17%.
Faba bean		
HFB-3 (HB 14-21)	Northern plain zone of the country (Haryana, Punjab, Delhi) and Central Zone (Uttar Pradesh and Chhattisgarh)	Suitable for irrigated, timely sown *rabi* season in high fertility conditions, average seed yield 23.65 q/ha, medium maturity (129 – 137 days), seed protein 28.05%, moderately resistant to *Alternaria* leaf blight, root rot.
Moth bean		
CZMO – 18-2 (CAZRI Moth – 4)	All Moth bean growing area of Country (Rajasthan, Gujarat, Maharashtra and Karnataka)	Suitable for rainfed condition, grain average seed yield 10-12 q/ha, maturity 83 days, resistance to foliar and root diseases of moth bean.
CZMO – 18-5 (CAZRI Moth – 5)	All Moth bean growing area of Country (Rajasthan, Gujarat, Maharashtra and Karnataka)	Suitable for rainfed condition, grain average seed yield 10.69 q/ha, maturity 73 – 84 days, resistance to all foliar and root diseases of moth bean.
Indian bean		
HA 5 (HA 10-2)	Karnataka	Suitable for Eastern dry zone (Zone 5) of Karnataka both under rainfed and irrigated ecosystems, average seed yield 3.0 q/ha in rainfed, 4.0 – 5.0 q/ha under irrigated conditions, maturity 80-90 days for fresh pod and 120-125 days for grain yield, tolerant to dry spells in Eastern dry zones of Karnataka.

Commercial crops: A total of 107 high-yielding varieties of commercial crops were released for different agro-ecological regions. These included 17 varieties of cotton, 72 of Bt cotton, 5 of jute, 1 of mesta (roselle), and 12 of sugarcane.

List of released varieties/hybrids of Commercial crops

Variety	Area of adoption	Salient features
Non Bt cotton varieties/hybrids		
Shalini (CNH 17395) (CICR-H Cotton 58)	Madhya Pradesh, Maharashtra and Gujarat	Suitable for rainfed *kharif* condition, average seed cotton yield 14.41 q/ha, maturity 160 to 165 days, brown linted naturally colour cotton suitable for handloom weaving, tolerant to sucking pests and bollworms. Resistant to *Alternaria* leaf spot (ALS), bacterial blight, *Corynespora* leaf spot in the central zone under rainfed conditions.
CICR-A NC Cotton 67 (CNA 1092)	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed condition, average seed cotton yield 10.32 q/ha, maturity 160 days, tolerant to drought, resistant to ALS and grey mold (GM).
CNH-18529 (CICR-H NC Cotton 64)	Chhattisgarh, Gujarat, Madhya Pradesh and Maharashtra	Suitable for rainfed and irrigated conditions, average seed yield 10.11 q/ha, maturity 160-165 days. Tolerant to aphids, jassids, whitefly, thrips, *Helicoverpa armigera*, pink bollworms, resistant/moderately resistant to *Alternaria* leaf spot, grey mildew, bacterial blight, *Corynespora* leaf spot, rust.
TSH 387 (SVPR 7)	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu	Suitable for irrigated conditions during *kharif*, winter and summer season, average seed cotton yield 21.28 q/ha, maturity 150 days, suitable for drought and waterlogging situation, moderately tolerant to leaf hopper and white fly.
TVH 007	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed condition, average seed cotton yield 14.39 q/ha, maturity 140-150 days. Resistant to *Myrothecium* leaf spot, *Alternaria* leaf spot, grey mildew, bacterial blight. Moderately resistant to jassids
VPT 2 (TVH 002)	Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 14.09 q/ha, maturity 140-150 days, resistant to *Myrothecium* leaf spot, *Alternaria* leaf spot, grey mildew, bacterial blight, moderately resistant to jassids.
Nandyal Cotton 26 (NDLH 2056- 4)	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 13.77 q/ha, maturity 160 days, medium tolerant to sucking pests like jassids, tolerant to bacterial leaf blight, alternaria leaf spot and grey mildew.
Nandyal Cotton 27 (NDLA 3104-4)	Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 9.28 q/ha, maturity 150 days, medium tolerant to sucking pests like jassids.
Nandyal Cotton 28 (NDLA-3116-3)	Madhya Pradesh, Maharashtra and Gujarat	Suitable for rainfed condition, average seed cotton yield 12.57 q/ha, maturity 150 days, medium tolerant to sucking pests like jassids, tolerant to bacterial leaf blight, *Alternaria* leaf spot and grey mildew.
Phule-Shubhra (RHB-1623)	Maharashtra and Gujarat	Suitable for irrigated condition, average seed cotton average seed cotton yield 19.18 q/ha, maturity 170-180 days, tolerant/resistant to: Alternaria leaf blight, bacterial leaf blight and gray mildew with extra-long staple.
Phule Ekata (RHB-1008)	Karnataka, Andhra Pradesh and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 17.02 q/ha, maturity 170-180 days, tolerant/resistant to major pests and diseases, extra long staple (ELS)
GN. Cot. 27 (Gujarat Navsari Cotton 27) (Surti Sonu) (GShv-331/14)	Gujarat	Suitable for *kharif*, average seed cotton yield 12.64 q/ha, maturity 170-180 days, disease free reaction to wilt, *Alternaria* leaf spot and bacterial leaf blight
Narmada Gold (G. Cot. 31) (GBhv 356)	Gujarat	Suitable for *kharif*, average seed cotton yield 13.99 q/ha, maturity 170-180 days, resistant to wilt, *Alternaria* leaf spot, bacterial leaf blight.
PA 833	Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 10.79 q/ha, maturity 150-160 days. Tolerant to bacterial blight, *Alternaria* leaf spot, sucking pests.
PDKV Dhawal (AKA-2013-8)	Madhya Pradesh, Maharashtra and Gujarat	Suitable for timely sown *kharif* under rainfed situation, average seed cotton yield 12.84 q/ha, maturity 160-180 days. Tolerant to leaf hoppers, bacterial leaf blight, *Myrothecium* leaf spot, *Alternaria* leaf spot, grey mildew.
PBD 88	Punjab, Haryana and Rajasthan	Suitable for irrigated condition under recommended planting system, average seed cotton yield 31.44 q/ha, maturity 160-170 days, desi variety, resistant to fungal foliar leaf spots and bacterial blight, less infestation of jassids.
NH -677	Maharashtra	*Gossypium hirsutum* variety suitable for intensive cultivation methods, average seed cotton yield 14-15 q/ha, maturity 165-170 days, GoT of 37.38%, fiber length 25.26 mm, tolerant to drought and sap sucking pests.

Variety	Area of adoption	Salient features
Bt cotton varieties/hybrids		
Rasi Max 009 BG II	Madhya Pradesh, Maharashtra and Gujarat, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 24.00 q/ha (Central India), 27.22 q/ha (Southern Zone), maturity 150 days, resistant to BLB, moderately resistant to ALS, GM, CoLS.
Rasi Max 066 BG- II	Madhya Pradesh, Maharashtra, Gujarat and Rajasthan, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 20.51 q/ha (CS), 21.54 q/ha (SZ), maturity 150 days, resistant to BLB, ALS, GM, CoLS TSV, Anthracnose.
RCH 990 BG- II	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 17.15 q/ha, maturity 150 days, resistant to ALB, BLB, GM, rust.
RCH 981 BG II	Madhya Pradesh, Maharashtra and Gujarat	Suitable for irrigated condition, average seed cotton yield 22.09 q/ha, maturity 150 days, resistant to ALS, BLB, CoLS, moderately resistant to GM.
RCH 983 BG II	Punjab, Haryana and Rajasthan	Suitable for irrigated condition, average seed cotton yield 28.94 q/ha, maturity 150 days, resistant to CLCuD, FFS, BLB.
RCH 1136 BG-II (Rasi Max 036 BG- II)	Punjab, Haryana and Rajasthan	Suitable for irrigated condition, average seed cotton yield 19.99 q/ha, maturity 150 days, tolerant/resistant to NIL, highly resistant to CLCuD.
RCH 1099 BG-11 (Rasi Max 006 BG-II)	SZ-Maharashtra, Madhya Pradesh and Gujarat CZ-Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 25.71 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, GM, CoLS and disease free to TSV. Suitable for irrigated condition, average seed cotton yield 25.12 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, BLB, CoLS, moderately resistant to GM.
RCH 1101 BG-II (RCH Max 001 BG-II)	Punjab, Haryana and Rajasthan	Suitable for irrigated condition, average seed cotton yield 28.88 q/ha, maturity 150 days, tolerant/resistant to NIL, highly resistant to CLCuD, resistant to FFS, BLB.
RCH 1139 BG-II (Rasi Max 039 BG-II)	Punjab, Haryana and Rajasthan	Suitable for irrigated condition, average seed cotton yield 20.79 q/ha, maturity 150 days, tolerant/resistant to NIL, highly resistant to CLCuD.
RCH 965 BG-II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated condition, average seed cotton yield 24.04 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant ALS, BLB/ moderately resistant to GM, CoLS, TSV.
RCH 999 BG-II	CZ-Maharashtra, Madhya Pradesh and Gujarat SZ-Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 25.47 q/ha (CZ), 26.25 q/ha (SZ), maturity 150 days, tolerant/resistant to NIL, resistant ALS, BLB/ moderately resistant to GM, CoLS, TSV.
RCH 997 BG- II	Punjab, Haryana and Rajasthan	Suitable for irrigated condition, average seed cotton yield 25.99 q/ha, maturity 150 days, tolerant/resistant to NIL, highly resistant to CLCuD.
RCH 1093 BGII (Rasi Max 033) BG-II)	CZ-Maharashtra, Madhya Pradesh, Gujarat and Rajasthan. SZ-Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	CZ-Suitable for rainfed condition, average seed cotton yield 22.44 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, CoLS, GM, CLS, Rust, TSV. SZ-Suitable for rainfed condition, average seed cotton yield 20.63 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALB, BLB, GM, rust.
RCH 1169 BG-II (Rasi Max 069) BG-II)	CZ-Maharashtra, Madhya Pradesh and Gujarat SZ-Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	CZ - Suitable for irrigated condition, average seed cotton yield 27.93 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, BLB, CoLS, TSV, moderately resistant to GM. SZ - Suitable for irrigated condition, average seed cotton yield 29.91 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, CoLS, GM, rust, TSV.
RCH 1103 BG-II (Rasi Max 003) BG-II	Punjab, Haryana and Rajasthan.	Suitable for irrigated condition, average seed cotton yield 29.15 q/ha, maturity 150 days, tolerant/resistant to NIL, highly resistant to CLCuD, resistant to FFS, BLB.
SP 7680 BG- II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 17.28 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, BLB, GM, rust.
SP 7688 BG- II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 18.46 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant ALS, BLB, GM, rust.
SP 7689 BG- II	Telangana	Suitable for rainfed condition, average seed cotton yield 26.11 q/ha, maturity 150 days, tolerant/resistant to NIL, resistant to ALS, BLB, GM, rust.
KCH 9111 BG II	Telangana, Andhra Pradesh Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 28.26 q/ha, compact hybrid suitable for HDPS, maturity 150-155 days, tolerant to *Alternaria* leaf spot, grey mildew, rust, boll rot, TSV, leaf hopper, thrips and whitefly.

Variety	Area of adoption	Salient features
KCH 9122 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 27.40 q/ha, maturity 160-165 days, tolerant to moisture stress, good tolerance to leaf hoppers, thrips and whitefly.
KCH 9355 BG II	Haryana, Punjab, Rajasthan	Suitable for normal sowing window, in irrigated condition, average seed cotton yield 21.69 q/ha, maturity 160-170 days, tolerant to leaf hopper, whitefly, sucking pests like aphids, jassids, thrips and whitefly.
KCH 301 BG II	Telangana, Andhra Pradesh Karnataka and Tamil Nadu	Suitable for rainfed/irrigated condition, average seed cotton yield 21.16 q/ha, maturity 160-165 days, tolerant to bacterial leaf blight, *Alternaria* leaf spot and grey mildew.
VSCH 219 BG II	Telangana, Andhra Pradesh, Karnataka and Tamilnadu	Suitable for irrigated conditions, average seed cotton yield 27.67 q/ha, maturity 135-140 days, tolerant to lodging and shattering, tolerant to sucking pests.
VSCH 139 BG II	Maharashtra, Gujarat, Madhya Pradesh And South Rajasthan, Andhra Pradesh	Suitable for rainfed condition, average seed cotton yield 20.09 q/ha (south zone), 21.34 q/ha (Central zone), maturity 120-135 days, compact hybrid suitable for HDPS, tolerant to *Fusarium* wilt, heavy response to fertilizers.
NCS 8022 Bt2	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated condition, average seed cotton yield 28.56 q/ha, maturity 140-150 days, compact hybrid suitable for HDPS, tolerant to sucking pests, diseases.
BIO GHH 101 BGII (BIO 6101 BGII)	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated condition, average seed cotton yield 21.29 q/ha, maturity 155-165 days, tolerant to major pests and diseases of cotton.
BIO 6802 BGII	Andhra Pradesh and Tamilnadu, Maharashtra, Gujarat, Madhya Pradesh and Rajasthan	Suitable for rainfed condition, average seed cotton yield 14.40 q/ha (South Zone) and 22.03 q/ha (Central Zone), maturity 150-165 days, tolerant to sucking pests and major diseases of cotton.
BIO 6938 BGII	Telangana, Andhra Pradesh, Karnataka and Tamil nadu	Suitable for irrigated and protective irrigated situations, average seed cotton yield 30.92 q/ha, maturity 155-165 days, highly tolerant to sucking pest complex.
ARCH 2020 BGII	Punjab, Haryana and Rajasthan State	Suitable for irrigated condition, average seed cotton yield 22.43 q/ha, compact hybrid suitable for HDPS, maturity 140-150 days, moderately resistant to CLCuD and tolerant to other diseases.
ARCH 844 BGII	Maharashtra, Madhya Pradesh, Gujarat and South Rajasthan	Suitable for rainfed condition, average seed cotton yield 21.67 q/ha, maturity 140-150 days, tolerant to major cotton pests and diseases.
ARCH 6651 BGII	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 24.65 q/ha, maturity mid-late (150-160 days), tolerant to major diseases of cotton.
ARCH 3224 BGII	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 20.80 q/ha, compact hybrid suitable for high density planting, maturity mid-late (150-160 days), tolerant to major disease of cotton.
ACH-27-2 BG-II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu, Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated timely sown condition, average seed cotton yield of 21.73 q/ha, maturity 140 days, resistant to grey mildew, *Alternaria* leaf spot, CoLS, bacterial leaf blight, tolerant to sucking pests of the cotton.
ACH-999-2 BG-II	Punjab, Haryana and Rajasthan	Suitable for *kharif* season under Irrigated timely sown (first fortnight of May) condition, average seed cotton yield 35.89 q/ha, maturity 150-160 days, highly resistant (HR) reaction for the CLCuV disease.
ACH-981-2 BG-II	Maharashtra, Gujarat and Madhya Pradesh, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 23.11 q/ha (CZ), 26.97 q/ha (SZ), maturity 150-160 days, tolerance to major diseases of cotton.
ACH-555-2 BG-II	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated timely sown condition, average seed cotton yield 17.57 q/ha, maturity 155-160 days, resistant to GM, ALB, BLB and *Ceircospora* leaf spot disease.
ACH-559-2 BG-II	Punjab, Haryana and Rajasthan	Suitable for *kharif* season under irrigated timely sown (first fortnight of May) condition, average seed cotton yield 27.56 q/ha, maturity 150-160 days, resistant to CLCuD disease.
ACH-909-2 BG-II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for *kharif* season under irrigated timely sown condition, average seed cotton yield 28.03 q/ha, maturity 145-155 days, resistant to GM, ALB, BLB, rust, TSV and CLS.
JEEO D-1199 BG II	Telangana, Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, Maharashtra and Gujarat	Suitable for irrigated condition, average seed cotton yield 21.40 q/ha, maturity 145-160 days, good fibre quality, resistant to major insect pests and diseases, big boll size.
Daftari 3099 BG II	Gujarat, Madhya Pradesh, Maharashtra and South Rajasthan	Suitable for rainfed condition, average seed cotton yield 20.37 q/ha, maturity 145-160 days, resistant to major insect pests and diseases, good fibre quality.

Variety	Area of adoption	Salient features
JKCH 18568 BGII	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Gujarat, and Madhya Pradesh	Suitable for irrigated *kharif* condition, average seed cotton yield 26.42 q/ha, maturity 151-165 days, resistant to bacterial leaf blight, *Alternaria* leaf spot, grey mildew, tobacco streak virus, *Corynespora* leaf spot, *Ceircospora* leaf spot, rust, boll rot, leaf hopper, aphids, thrips, white fly, *Helicoverpa armigera*, spotted bollworm, *Spodoptera litura* and natural enemies.
SS 1188 BGII	Maharashtra, Gujarat and Madhya Pradesh, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated conditions, average seed cotton yield 23.9 q/ha, maturity 155 - 165 days, tolerant to important insects, viz. leaf bopper, jassids, thrips, white fly and aphids, resistant to all cotton diseases under study, viz. BLB, ALB, GM, CoLS and TSV.
SS-963 Bt2	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 21.87 q/ha, maturity 150-160 days, tolerant to *Alternaria* leaf blight, grey mildew and rust.
C 7938 BG-II (HxB)	SZ - Karnataka and Tamilnadu	SZ - Suitable for irrigated condition, average seed cotton yield 15.53 q/ha, maturity 170-180 days, resistant to bacterial blight, *Alternaria* leaf spot, grey mildew.
	CZ - Maharashtra and Gujarat	CZ - Suitable for irrigated condition, average seed cotton yield 17.81 q/ha, maturity 180 days, resistant to bacterial leaf blight, grey mildew, *Alternaria* leaf spot.
C 9314 BG-II	Punjab, Haryana and Rajasthan	Suitable for early to timely sowing conditions, average seed cotton yield 27.20 q, maturity 155-160 days, moderately tolerant to stress like conditions including moisture, heat, waterlogging, resistant to bacterial blight.
CICR- H Bt Cotton 40 (ICAR-CICR- PKV 081 Bt)	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 17.30 q/ha, maturity 140 to 150 days, resistant to jassids, thrips, whitefly, aphids, tolerant to bacterial leaf blight, *Alternaria* leaf blight, grey mildew.
US 711 BG-II	Maharashtra, Madhya Pradesh and Gujarat	CZ - Suitable for irrigated condition, average seed cotton yield 23.58 q/ha, maturity 150 days, resistant to ALS, BLB, GM, TSV, moderately resistant to CoLS.
	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	SZ - Suitable for irrigated condition, average seed cotton yield 26.74 q/ha, maturity 150 days, resistant to ALS, TSV, GM.
US 707 BG-II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 26.54 q/ha, maturity 150 days, resistant to ALS, BLB, GM.
CICR-H Bt Cotton 65 (ICAR -CICR 18 Bt)	Madhya Pradesh, Maharashtra and Gujarat	Suitable for rainfed condition, average seed cotton yield 15.47 q/ha, maturity 140-150 days, resistant to most of the diseases, viz. bacterial blight, grey mildew, *Alternaria*, *Corynospora* leaf spot, *Myrothecium,* tolerant to most of the pests, viz. jassids, aphids, thrips, leaf hopper.
CICR- H Bt Cotton 66 (CICR Bt 20-31)	Central zone (states Maharashtra, Madhya Pradesh, Gujarat)	Suitable for rainfed *kharif* condition, average seed cotton yield 14.45 q/ha, maturity 140-150 days, resistant to most of the diseases, viz. bacterial blight, grey mildew, *Alternaria*, *Corynospora* leaf spot, *Myrothecium,* tolerant to most of the pests, viz. jassid, aphids, thrips, leaf hopper.
DC 5100 BGII	Maharashtra, Gujarat and Madhya Pradesh., South Rajasthan, Telangana, Andhra Pradesh, Karnataka, and Tamil nadu	Suitable for irrigated condition, average seed cotton yield 24.68 q/ha (CZ) and 26.89 q/ha (SZ), maturity 160-165 days, tolerant to major insect pests and diseases of cotton.
DC 5101 BGII	Maharashtra and Gujarat	Suitable for rainfed condition, average seed cotton yield of 21.1 q/ha, maturity 150-155 days, tolerant to leaf hopper, thrips, white fly, bacterial leaf blight, *Alternaria* leaf spot, boll rot,
ARCH 3028 BG II	Madhya Pradesh, Maharashtra and Gujarat	Suitable for irrigated condition, average seed cotton yield 23.45 q/ha, maturity 160-165 days, tolerant to major pest and diseases, Special features: Bt Cotton Hybrid.
ARCV 22 Bt	Rajasthan, Haryana and Punjab	Suitable for irrigated early–mid late sowing during *kharif*, average seed cotton yield 27,46 q/ha, maturity 155-160 days low to high fertility, highly resistant to CLCuD.
G Cot 10 Bt Bt	Madhya Pradesh, Maharashtra and Gujarat	Suitable for *kharif* irrigated condition, average seed cotton yield of 13.94 q/ha, seed to seed maturity 160-180 days, resistant/moderately resistant to bacterial leaf blight, *Alternaria* leaf spot, grey mildew, resistant to MLS and CoLS.
Daftari 2244 BG II	Telangana, Andhra Pradesh and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 22.33 q/ha, maturity 140-160 days, excellent fibre quality, big boll size, resistant/tolerant to major pests and diseases.
Hy. Daftari 1579 BG II	Maharashtra Madhya Pradesh and Gujarat	Suitable for irrigated condition, average seed cotton yield 20.81 q/ha, maturity 140-160 days, excellent fiber quality, resistant to pests and diseases, big boll size.
NH 1901 Bt	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed, average seed cotton yield 14.74 q/ha, maturity 160-165 days, medium to high fertility, *kharif* season, tolerant to bacterial blight, *Alternaria* leaf spot, sucking pests.

Variety	Area of adoption	Salient features
NH 1902 Bt	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed medium to high fertility *kharif* season, average seed cotton yield 15.09 q/ha, maturity 160-165 days, tolerant to sucking pests.
NH 1904 Bt	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed medium to high fertility *kharif* season, average seed cotton yield 13.84 q/ha, maturity 160-165 days, tolerant to bacterial blight, *Alternaria* leaf spot, sucking pests.
C 376 BG II	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 24.4 q/ha, maturity 160-170 days, tolerant/resistant to bacterial leaf blight, *Alternaria* leaf spot, grey mildew, TSV incidence, rust.
Ajeet 9-2 BG II (ACH-9-2)	Maharashtra, Gujarat and Madhya Pradesh and Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated condition, average seed cotton yield 24.64 q/ha, maturity 145-155 days, tolerant/resistant to grey mildew, *Alternaria* leaf spot, circospora leaf spot (CoLS) and bacterial leaf blight.
Ajeet-902-2 BG II (ACH 902-2)	Punjab, Haryana and Rajasthan	Suitable for irrigated timely sown condition, average seed cotton yield 29.62 q/ha, maturity 150-160 days, high and stable yields, excellent fibre properties, resistant to CLCuV, tolerant to sucking pests.
MC 5410 BG II	Punjab, Haryana and Rajasthan	Suitable for irrigated condition of *kharif* season, average seed cotton yield of 30.8 q/ha, maturity 150-155 days, resistant to bacterial leaf blight, fungal foliar diseases.
MC 5444 BG II	Andhra Pradesh Tamil Nadu and Telangana	Suitable for irrigated condition of *kharif* season, average seed cotton yield of 22.2 q/ha, maturity 150-165 days, resistant to *Alternaria* leaf blight, grey mildew, *Alternaria* leaf spot, *Cercospora* leaf spot, *Corynespora* leaf spot, rust, boll rot.
MC 5500 BG II	Karnataka, Tamil Nadu and Andhra Pradesh	Suitable for irrigated condition of *kharif* season, average seed cotton yield of 18.8 q/ha, maturity 175-180 days, resistant/disease free for *Alternaria* leaf blight, bacterial leaf blight grey mildew, *Alternaria* leaf spot, *Cercospora* leaf spot, *Corynespora* leaf spot, rust, tobacco streak virus, boll rot.
KCH 9322 BG II	Haryana, Punjab and Rajasthan	Suitable for irrigated condition, average seed cotton yield 25.89 q/ha, maturity 160-170 days, resistant to CLCuD.
KCH 9344 BG II	Haryana, Punjab and Rajasthan	Suitable for irrigated condition average seed cotton yield 15-20 q/ha, maturity 155-165 days, resistant to CLCuD.
ATCH- 1365 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated condition, average seed cotton yield 15-20 q/ha, maturity 160-165 days, resistant to para wilt and sucking pests, tolerant to lodging.
60 SS 66 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, average seed cotton yield 15-20 q/ha, maturity 150-170 days, long staple, good bundle strength, moderately resistant to *Alternaria* leaf blight, BLB, grey mildew and rust.
SS-246 Bt2	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for both rainfed and irrigated condition, both high and low fertility soil during *kharif* season, average seed cotton yield 15-20 q/ha, maturity 150-160 days, tolerant to sucking pest, resistant to lodging and shattering, highly responsive to fertilizers.
Jai Ho BGII	CZ - Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated condition, average seed cotton yield 20.38 q/ha, maturity 155-160 days, tolerant to sucking pests of cotton and resistant to *Alternaria* leaf spot, grey mildew and bacterial leaf blight.
Sugarcane		
Genda (CoSe 11453)	Eastern Uttar Pradesh, Bihar, West Bengal and Assam	Suitable for normal irrigated condition and autumn and spring planting, average cane yield 781.9 q/ha, maturity 360 days, moderately resistant for early shoot borer, stalk borer, root borer and top borer.
Divyashi - CoN 15071 (GNS-12)	South Gujarat	Suitable for irrigated condition, average cane yield 1,293.4 q/ha, sugar yield 163.8 q/ha, maturity 330 to 360 days, tolerant to drought and salinity, non-lodging and non-flowering, good for mechanical harvesting and protection against wild boar, moderately resistant to red rot, wilt, resistant to smut.
CoVC 18061	Irrigated areas of southern Karnataka	Suitable for all the planting seasons, average cane yield 1,700-1,800 q/ha, mid-late maturing (12–14 months), clone with sparse and late flowering, excellent for jaggery making, good ratooner.
Karan 17 (Co 17018)	Haryana, Punjab, western and central Uttar Pradesh, Rajasthan, Uttarakhand	Suitable for irrigated timely to late sown season, average cane yield 914.8 q/ha, maturity 330-360 days, sucrose 18.38%, commercial cane sugar (CCS) 12.78%, tolerant to salinity, resistant to moderately resistant to red rot, resistant to moderately resistant to YLD, least susceptible to shoot borer, stalk borer and top borer.
Roshan (CoS 16233)	Punjab, Haryana, Uttrakhand, Rajasthan, Central and Western part of Uttar Pradesh	Suitable for irrigated condition, average cane yield 923.8 q/ha, CCS 120.1 q/ha, sucrose in juice 18.73%, maturity mid-late (12–14 months), resistant reaction to red rot, less susceptible in reaction of major insect-pests.
IKHSU-16 (CoLk 16202)	Punjab, Haryana, Uttarakhand, Rajasthan, Central and Western Parts of Uttar Pradesh	Suitable for irrigated condition, average cane yield 932 q/ha, maturity early (10 months), sucrose (%) 17.74, CCS 114.3 q/ha, tolerant to drought, moderately resistant to CF08 and CF13 of red rot pathogen, smut, wilt.

Variety	Area of adoption	Salient features
IKHSU-17 (CoLk 16470)	Eastern Part of Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for irrigated condition, average cane yield 825.0 q/ha, CCS yield 95.9 q/ha, sucrose 17.37%, maturity 360 days, excellent performance under waterlogged condition, moderately resistant to red rot, smut, least susceptible to major insect-pests.
CoPb 99 (CoPb 17215)	Punjab, Haryana, Uttarakhand, Rajasthan, Central and Western Parts of Uttar Pradesh	Suitable for growing in medium and high fertile soil under irrigated subtropical climatic conditions during spring season, average cane yield 901.4 q/ha, CCS 112.7 q/ha, , sucrose 18.01%, maturity mid-late (12 months), moderately resistant/resistant to prevalent races of red rot, less susceptible towards early shoot borer, stalk borer and top borer.
SNK 09211 (CoSnk-15102)	Karnataka Zone- 3 and 8	Suitable for using as early maturing variety as well as taking 3 crops in two years, average cane yield 1,030 q/ha, maturity 300 days, drought tolerant, moderately resistant to lodging, moderately resistant to red rot, less susceptible to early shoot borer.
SNK 09227 (CoSnk-15104)	Karnataka Zone- 3 and 8	Suitable for irrigated and moisture stress condition, average cane yield 1,335 q/ha, maturity 360 days (mid-late variety), moderately resistant to lodging, tolerant to moisture stress, suitable for planting and harvesting throughout year, moderately susceptible to red rot, less susceptible to early shoot borer.
Sharad SNK 09293 (CoSnk-09293)	Karnataka Zone- 3 and 8	Suitable for irrigated condition, average cane yield 1,060 q/ha, maturity 360 days, withstand waterlogged-salinity complex for few days, moderately resistant to smut, rust, brown spot and tolerant to foliar diseases.
Phule Sugarcane- 15012 (MS- 17082)	Maharashtra	Suitable for irrigated and semi-irrigated condition, average cane average cane yield 1,404.6 q/ha, maturity 360 days, non-lodging, moderately resistant to wilt and red rot, less susceptible to early shoot borer, internode borer, top shoot borer and scale insects.
Fibre crops/jute and allied crops		
Jute		
JROP-4 (Renuka)	Assam, West Bengal, Bihar, Tripura, Uttar Pradesh and Odisha	Suitable for sowing from mid-March to end of April in irrigated/rainfed ecosystem, average fiber yield 31.24 q/ha, fiber crop maturity 110–130 days, higher resistance to stem rot and root rot. First proposed variety for bio-fortified jute as vegetable crop.
JROV-5 (Vitapat-1) Bio fortified	West Bengal, Assam, Bihar and Odisha	Suitable for rainfed/irrigated condition for growing from March to September as vegetable crop, fresh leafy vegetable yield 151.31 q/ha, maturity 30 days, first bio-fortified tossa jute variety with rich source of vitamin C content (1.05 mg/g fresh leaf wt).
JRCP-7 (Arijit)	West Bengal, Assam, Bihar, Odisha, Tripura, Uttar Pradesh and Madhya Pradesh	Suitable for producing white jute fiber with higher strength without compromising fiber fineness, average fiber yield 31.48 q/ha, fiber maturity 110-120 days, higher resistance to insect pests like Bihar hairy caterpillar, yellow mite and stem weevil and tolerance to stem rot, and root rot diseases.
NJ 7068	West Bengal, Bihar, Assam, Odisha, Maharashtra	Suitable for timely sown rainfed/irrigated condition, average fiber yield 32.19 q/ha, maturity 115 –120 days (fiber), 140-145 days (seed), fiber fineness 3.04 tex, fibre strength 17.78 g/tex, tolerant to stem rot, less infestation of semilooper.
JRC 9 (Namita)	West Bengal, Odisha, Bihar, Uttar Pradesh, Tripura and Assam	Suitable for timely sown rainfed/irrigated condition, average fiber yield 31.97 q/ha, maturity 110–120 days (fibre), 120-130 days (seed), fibre fineness 1.74 tex, fibre strength 13.88 g/tex, tolerant to stem rot and root rot, tolerant to yellow mite, Bihar hairy caterpillar, jute semilooper.
Mesta (Roselle)		
JBMP-6 (Titli) (JRK-2017-2)	West Bengal, Odisha, Maharashtra, Andhra Pradesh, Bihar and North-Eastern regions	Suitable for mid to high land rainfed agro-ecological region, average fiber yield 28.06 q/ha, maturity 120-130 days, tolerant to foot and stem rot disease, aphids, semilooper and mesta mealy bug.

Forage and other crops: A total of 47 high-yielding varieties of forage and other crops were released for different agro-ecological regions. These included 5 varieties of forage pearl millet, 6 of forage maize, 13 of forage sorghum, 7 of grain amaranth, 2 each of winged bean and tobacco, and 1 each of kalingda and asalio.

List of improved released varieties/hybrids of Forage and other crops

Variety	Area of adoption	Salient features
Oats		
HFO 906	Rajasthan, Haryana, Punjab and Tarai Part of Uttarakhand	Suitable for single cutting, average green fodder yield 655.1 q/ha, dry matter yield 124.4 q/ha, average grain yield 27.4 q/ha, high crude protein yield (11.4 q/ha), protein 10%, moderately resistant to *Helminthosporium* leaf blight.

Variety	Area of adoption	Salient features
Him Palam Forage Oat-1 (PLP-24)	Himachal Pradesh, Jammu and Kashmir and Uttarakhand	Suitable for timely sown, normal fertility and irrigated condition average green fodder yield, yield 260-300 q/ha, maturity 180-185 days, resistant to powdery mildew.
Jawahar Oat- JO 07-310	Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur	Suitable for all parts of fodder growing area in Madhya Pradesh, average green fodder yield 575-600 q/ha, maturity 130-140 days, moderately resistant to leaf spot, blight.
Jawahar Oat 13-513 (JO-13-513)	Punjab, Haryana, Uttar Pradesh, Uttarakhand, Odisha, Bihar, Jharkhand, Assam and Uttar Pradesh	Suitable for oat growing areas of eastern and north-western zone, yield 225-250 q/ha (green fodder yield), maturity 135-145 days, moderately resistance to leaf blight.
Shalimar Fodder Oats 7 (SKO-244)	Jammu and Kashmir	A single cut variety suitable for timely sown, normal fertility and irrigated conditions average green fodder yield 455.2 q/ha, dry matter yield 94.6 q/ha, seed yield 2.50 q/ha, maturity 170 days (fodder), 230 days (seed to seed), resistant reaction to various diseases and pests.
Forage sorghum		
Banas Chari Gujarat Forage Sorghum 8 (GFS 8) (DSF 168)	Gujarat	Suitable for irrigated/rainfed/timely sown conditions of Gujarat state, average green forage yield 489 q/ha, dry fodder yield 177 q/ha, maturity medium 65-75 days, better Brix content (11.1%), protein 6.1%, moderately tolerant to insects and foliar diseases.
Forage Sorghum 9 (UTMC 539)	Uttarakhand	Suitable for cultivation under irrigated summer condition, average green fodder yield 700-800 q/ha, dry matter yield 195-225 q/ha, maturity 75 days**,** protein content (7.29%) resistant to major foliar diseases.
Forage Sorghum 10 (UTMC 552)	Uttarakhand	Suitable for cultivation under irrigated summer condition, average green fodder yield 750-800 q/ha, dry matter yield 175-225 q/ha, multi-cut variety with Tan type plant, protein content (7.16%).
Forage Sorghum 11 (UTMC 554)	Uttarakhand	Suitable for cultivation under irrigated summer condition, average green fodder yield 800-875 q/ha and dry fodder yield 190-250 q/ha, multi-cut variety with Tan type plant, protein yield (20.16 q/ha), resistant to major foliar diseases.
SX 21 (CFSH 50) (SPH 1970) (CSH 51 MF)	Gujarat, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Rajasthan, Tamil Nadu, Karnataka, Telangana and Maharashtra	Suitable for all India cultivation during spring/*kharif* seasons, average green fodder yield 895 q/ha, dry fodder yield 224 q/ha, protein yield of 17.77 q/ha, multicut forage sorghum hybrid, tolerant to major foliar diseases and insect pests.
CSH 50 F (SPH 1985-ADV 6610)	Karnataka, Tamil Nadu, Telangana and Maharashtra	Suitable for irrigated condition, average green fodder yield 357 q/ha, dry matter yield 143 q/ha, maturity 110-120 days, single cut forage sorghum hybrid with high biomass yield and quality parameters with pest and disease resistance, tolerance to major foliar diseases and insect pests.
CSH 52- MF (SPH 1967-ADV 6690)	Uttarakhand, Punjab, Haryana, Rajasthan, Gujarat, Karnataka, Tamil Nadu, Telangana and Maharashtra	Suitable for irrigated condition, average green fodder yield 980 q/ha, dry matter yield 23.3 q/ha, multi-cut forage sorghum hybrid with high biomass yield, tolerant to major pests and diseases.
Jamboo Diamond (CSH 53 MF) (SPH 1966) (ADV 6606)	Karnataka, Tamil Nadu, Telangana and Maharashtra	Suitable for irrigated condition, average green fodder yield 92.6 q/ha; dry fodder yield 26.6 q/ha, medium maturity (120 days), multi-cut forage sorghum hybrid with high biomass yield and quality parameters, tolerant to major pests and diseases.
CSH 54 BMR (SPH 1991-ADV 6604)	Uttarakhand, Punjab, Haryana and Rajasthan, Gujarat, Tamil Nadu, Telangana and Maharashtra	Suitable for irrigated condition, average green fodder yield 398 q/ha; dry fodder yield 13.3 q/ha, maturity 86 days (days to 50% flowering), brown midrib (BMR) forage sorghum hybrid with high biomass yield.
CSV 56F (SPV 2800) (UTFS 110)	Gujarat, Uttar Pradesh, Rajasthan and Delhi	Suitable for rainfed *kharif*, average green fodder yield 425 q/ha, dry fodder yield 134 q/ha, maturity 120-125 days, tolerant to major leaf disease, viz. grey leaf spot, sooty stripe, *Anthracnose*, zonate leaf spot, tolerant to shoot fly, stem borer.
SL 46	Punjab	Suitable for all fodder growing irrigated areas of Punjab, average green fodder yield 689.4 q/ha, late maturity 93 days (days to 50% flowering), resistant to red leaf spot and moderately resistant to zonate leaf spot, moderately resistant to shoot fly.
CSV 57F (SPV 2801) (UTFS 111)	Haryana, Punjab, Uttarakhand, Gujarat, Uttar Pradesh, Rajasthan and Delhi	Suitable for rainfed *kharif* season, average green fodder yield 435 q/ha, dry fodder 139 q/ha, maturity 130-135 days, tolerant to major leaf disease, viz. grey leaf spot, sooty stripe, *Anthracnose*, zonate leaf spot, tolerant to shoot fly, stem borer.
CNFS-1 (Chamaraja Nagara Fodder Sorghum-1)	Karnataka (Zone- 6)	Suitable for rainfed areas of Southern dry zone of Karnataka, average green fodder yield 560-580 q/ha, dry fodder 140-150 q/ha, maturity 75-80 days, resistance to leaf bligh, foliar diseases and shoot fly.

Variety	Area of adoption	Salient features
Forage pearl millet		
ADV 984 (16ADV 0111) Hybrid	Punjab, Haryana, Rajasthan, plain parts of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Assam, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka	Suitable for irrigated/rainfed *kharif* and summer seasons, average green forage yield 464.1 q/ha (all India), 522.2 q/ha (North-West), 427.8 q/ha (North-East), 486.7 q/ha (Central) and 383.7 q/ha (South), maturity 80-105 days, tolerant to major foliar disease (blast, rust and DM), no major pest infestation, non-lodging, highly responsive to fertilizers, tolerant to drought, long and stay green fodder with more leaf: stem ratio of 0.51.
JPM 18-7 (Jawahar Pearl Millet 18-7)	Rajasthan, Punjab, Haryana, Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Chhattisgarh, Telangana, Andhra Pradesh, Tamil Nadu and Karnataka	Suitable for rainfed/irrigated under normal fertility condition during rainy season, green fodder yield 440-480 q/ha, maturity 120-130 days, moderately resistant to leaf blast, grasshopper, pyrilla and leaf defoliators.
Jawahar Pearl Millet 18-37 (JPM 18-37)	Rajasthan, Punjab, Haryana and parts of Uttrakhand	Suitable for rainfed and irrigated under normal fertility condition during rainy season, average green yield 500-550 q/ha, maturity 120-130 days, resistant to leaf blast, grasshopper.
PHBF 5 (PCB 168)	All fodder growing irrigated areas of North West zone (Punjab, Haryana, Rajasthan and Uttarakhand)	Suitable for irrigated areas during *kharif* season, green fodder yield 473 q/ha, dry matter yield 93 q/ha, crude protein yield 7.89 q/ha, average seed yield 15.2 q/ha, cutting of fodder 60 days of sowing, grain crop maturity 125 days, moderately resistant to leaf blast, downy mildew and tolerant to pyrilla and grasshopper.
FBL 4 (PCB 166)	Punjab, Haryana, Rajasthan and Uttarakhand, Tamil Nadu, Telangana, Andhra Pradesh and Karnataka)	Suitable for high irrigated areas during *kharif* season, maturity seed to seed -120-130 days, cutting of fodder 60 days of sowing, grain crop maturity 125 days, green fodder yield 436 q/ha, dry matter yield 85.5 q/ha, crude protein yield 8.44 q/ha, seed yield 16.8 q/ha, moderately resistant to leaf blast, downy mildew and tolerant to pyrilla and grasshopper.
Forage maize		
Gujarat Fodder Maize 1 AFM-23 (GFM 1: Anand Tall)	Gujarat	Suitable for timely sown (onset of monsoon) irrigated condition, average green fodder yield 446.81 q/ha and 81.13 q/ha under middle Gujarat conditions, maturity 95-105 days, contains higher dry matter (17.43%), neutral detergent fiber (76.09%), good crude protein (5.26%), acid detergent fiber (39.92%), *in vitro* dry matter digestibility 61.05%, tolerant to maydis leaf blight, fall armyworm and lower aphid damage.
J 1008 (PFM- 12)	Punjab	Suitable for irrigated *kharif* conditions, average green fodder yield 396.4 q/ha, maturity 74 days (medium), moderately resistant to maydis leaf blight.
HQPM 28	Uttar Pradesh (Bundelkhand region), Maharashtra, Madhya Pradesh, Chhattisgarh	Recommended for *kharif* season, average green fodder yield 427.6 q/ha, dry matter yield 79.06 q/ha, average seed yield 20.9 q/ha and crude protein 7.0 q/ha, maturity 98 days, three-way Quality Protein Maize (QPM) hybrid, good for silage, resistant to maydis leaf blight, BLSB and at par with checks for resistance against fall armyworm.
Pant Forage Maize Hybrid 1 (DFH-2)	Haryana, Punjab, Rajasthan, Uttarakhand Tarai region, Chhattisgarh, Madhya Pradesh, Maharashtra, Uttar Pradesh	Suitable for *kharif*, average green fodder yield 511.1 q/ha (NWZ), 378.9 q/ha (CZ), average dry matter yield 119.2 q/ha (NWZ), 83.3 q/ ha (CZ), 9.57q/ha (crude protein in NWZ), crude protein 7.04 q/ha (CZ), maturity 57 – 60 days, resistant to moderately resistant reaction to *Maydis* leaf blight, *Turcicum* leaf blight, resistant reaction to banded leaf and sheath blight (BLSB) in CZ, resistant to moderately susceptible reaction to fall armyworm and infestation/dead heart against *Chilo partellus.*
Pusa Forage Maize Hybrid-1 (AFH-7)	Tarai region of Uttarakhand, Punjab, Haryana and Rajasthan	Suitable for irrigated *kharif* season, average green fodder yield 413.1 q/ha, maturity 95-105 days, higher acid detergent fiber (ADF) - 41.9%, neutral detergent fiber (NDF) - 62.5%, *in-vitro* dry matter digestibility (IVDMD)-56.4%, resistant to *Maydis* leaf blight, moderately resistant to *Chilo partellus.*
J 1009 (PFM 13)	Chhattisgarh, Madhya Pradesh, Maharashtra and Uttar Pradesh	Suitable for highly fertile irrigated areas in *kharif*, average seed yield 14.3 q/ha, green fodder yield 355.3 q/ha, dry matter yield 75.8 q/ha, crude protein yield 6.0 q/ha, late maturing takes 72 days from seed to cutting, 124 days from seed to seed, tolerant for fall armyworm and moderately resistant to *Maydis* leaf blight.
Lucerne		
Baif Lucerne-5	Punjab, Haryana and Rajasthan	Suitable as perennial, multi-cut crop, average green fodder yield 625-630 q/ha, duration - 3 years, perennial, moderately resistant to weevil, pod borer.

Variety	Area of adoption	Salient features
IGFRI-DL-5	Karnataka	Suitable for north transitional zone (zone 8) and north dry zone (zone 3) of Karnataka under irrigated conditions, perennial (winter sown), average green fodder yield 900-1,000 q/ha/year (in 8-10 harvests), a perennial legume, first cut 55-60 DAS, subsequent cuts 25-30 days interval, crude protein 15-20%, IVDMD (65-68%), resistant to rust and moderately resistant to aphids.
Berseem		
BL 46 (BM 14)	Punjab, Haryana, Rajasthan, Uttarakhand, Uttar Pradesh, Jharkhand, Bihar, Odisha, West Bengal Maharashtra, Madhya Pradesh and Chhattisgarh	Suitable for high fertility irrigated areas during winter season, average green fodder yield 670.6 q/ha, dry matter yield 90.65 q/ha, maturity 264 days, resistance to biotic and abiotic stresses.
Jawahar berseem 07-15 (JB 07-15)	West Bengal, Jharkhand, Bihar, Odisha Madhya Pradesh, Gujarat, Maharashtra, Chhattisgarh and Uttar Pradesh	Suitable for irrigated multi-cut during winter season, average green fodder yield 620-680 q/ha, maturity 190-200 days, moderately resistant to stem and root rot.
Jawahar berseem 08-17 (JB 08-17)	Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh and Uttar Pradesh	Suitable for irrigated multi-cut during winter season, average green fodder yield 620-650 q/ha, maturity 190-200 days, tolerant to leaf spot and blight.
Others crops		
Grain amaranth		
RMA 62 (Jodhpur Rajgira 1)	WZ (Rajasthan, Gujarat); NPZ (Uttar Pradesh.); EZ (Odisha) and CZ (Part of Chhattisgarh)	Suitable for timely sown during *rabi* irrigated low fertility plains average grain yield 14.01 q/ha, maturity early (117-131 days), high protein content 11.83%, oil content 7.84% and lysine content 5.17%, no major disease and insect pests observed.
RMA 120 (Jodhpur Rajgira 2)	WZ (Rajasthan, Gujarat, Maharashtra); NPZ (Uttar Pradesh); EZ (Odisha, Jharkhand) and CZ (Chhattisgarh)	Suitable for plain areas of the country in *rabi* irrigated high fertility condition, average grain yield 14.05 q/ha, maturity early (119-128 days), high protein content (12.60%), oil content (8.33%) and lysine 4.72%, no major disease and insect pests observed.
Gujarat Amaranth 8 (GA 8) SKNA 1407	WZ (Gujarat, Rajasthan, Maharashtra), NPZ (Uttar Pradesh, CZ (Chhattisgarh), EZ Jharkhand and Odisha)	Suitable for cultivation in plain areas of the country in *rabi* season, average grain yield 14.55 q/ha, maturity 97 – 168 days (mean 127.33 days), protein content 12.21, oil content 8.09% and lysine content 5.03%, least incidence of insect pests and diseases.
Gujarat Amaranth 9 SKNA 1701	WZ (Gujarat, Maharashtra), NPZ (Uttar Pradesh), CZ (Chhattisgarh), EZ Jharkhand and Odisha) states during *rabi* season.	Suitable for cultivation in plain areas of the country in *rabi* season, average grain yield 14.12 q/ha, maturity 102-174 days, protein content 12.51, oil content 7.89% and lysine content 4.69%, least incidence of insect pests and diseases.
Him Gauri (IC037156)	Himachal Pradesh and Uttarakhand	Suitable for grain purposes cultivation during rainfed *kharif* season in mid to high hilly areas, average grain yield 24.06 q/ha, maturity 128.46 days, significantly higher lysine content (7.18 g/16 g N), higher total protein content (13.52 %), no disease or insect pest infestation reported.
VL Chua 140	Uttarakhand, Himachal Pradesh	Suitable for rainfed *kharif* ecology, average grain yield 16.86 q/ha, maturity 125-127 days, fertilizer responsive, no major insect pests and disease incidence was reported at any of the location.
Gujarat Amaranth 7 (GA 7) SKNA 808	Karnataka (South Zone)	Suitable for cultivation in plateau areas in *kharif*, average grain yield 15.91 q/ha, maturity 94 days, high protein (12.56%) and oil (8.19%), no major insect pest and disease observed under field conditions.
Kalingada		
SKNK 1407 (Gujarat Kalingada 3)	WZ (Gujarat and Rajasthan state	Suitable for rainfed *kharif* season, average seed yield 2.17 q/ha, fruit yield 89.81 q/ha, maturity 77-87 days, tolerant to drought, seeds contain higher amount of oil (33.35 %), protein, (18.13%), Fe (5.97 mg/100 g), good amount of crude fiber, phenol, Zn, lysine, no major diseases and insect-pests were observed.
Asalio		
Jodhpur Asaliya 1	Rajasthan	Suitable for timely sowing condition, resistant against downy mildew in field conditions, average seed yield 14.12 q/ha, maturity 117-125 days.
Winged bean		
PWB 17-18 (Phule Shrawani)	WZ (Maharashtra), NPZ (Uttar Pradesh), CZ (Chhattisgarh) and EZ (Jharkhand state)	Suitable for irrigated well-drained soil having medium fertility in *kharif* season, average seed yield 13.81 q/ha, green pod yield 142.96 q/ha, maturity late-160–168 days (seed), 85–95 days (seed to pod), contains 24.95% protein, 16.01% oil, no disease and pests observed.
Birsa Kamrenga – 1 (RWB-13)	EZ (Jharkhand)	Suitable for upland rainfed, *kharif* acidic soil, average seed yield 14.3 q/ha, maturity 162 days, tolerant to pod borer.

Variety	Area of adoption	Salient features
Tobacco		
FCR- 15 (CTRI Sreshta)	Recommended for Southern Light Soil tobacco growing areas of Prakasam and Nellore districts of Andhra Pradesh under rainfed condition.	Suitable for timely sown rainfed condition, yield (cured leaf) 21.13 q/ha, maturity (seed to seed) 165-170 days, nicotine 2.0 to 2.69, resistant to Tobacco Mosaic Virus.
FCJ- 11 (CTRI Naveena)	Recommended for Southern Light Soil tobacco growing areas of Prakasam and Nellore districts of Andhra Pradesh under rainfed condition.	Suitable for timely sown irrigated condition, yield (cured leaf) 33.09 q/ha, maturity (seed to seed) 170-180 days, nicotine 1.9 to 2.51.

Seed Production

Breeder seed production: During 2023-24, total breeder seed production in field crops was 1,06,397.6 q against the indent of 62,104.7 q.

Crop group	Indent for breeder seed (q)	Breeder seed produced (q)
Cereals	29,726.1	53,967.3
Oilseeds	21,173.3	36,276.9
Pulses	10,476.0	14,961.6
Fibres	53.4	150.6
Forages	675.8	1,041.2

Quality seed production: During the year 2023-24, total production of quality seed including all classes was 4,28,046.0 q against the target of 3,71,387.9 q. Production comprises 1,11,610.1 q of foundation seed, 1,41,685.5 q of certified seeds, 1,08,960.7 q of truthfully labelled seed and 65,789.8 q of planting material of field crops. In addition, 103.9 lakh planting material and 10.4 lakh tissue culture plantlets were produced against the targets of 70.4 and 9.7 lakh, respectively.

Crop Biotechnology

Functional validation of chitinase gene (*OsChib1*): A novel chitinase gene, *OsChib1*, located on chromosome 10 and belonging to GH18 (class IIIb) chitinases, was identified in the rice line Tetep through transcriptomic and targeted gene expression analyses. Overexpression of *OsChib1* conferred resistance against sheath blight disease caused by *Rhizoctonia solani* AG1-IA. It is the first functional validation of a class IIIb chitinase (*OsChib1*) in rice.

Identification of novel resistance loci for *Septoria tritici* blotch in Asian wheat via GWAS: A novel resistance loci for quantitative resistance to *Septoria tritici* blotch (STB) in Asian wheat (*Triticum aestivum*) was identified via genome-wide association studies (GWAS). Among 21 stable quantitative trait nucleotides (QTNs) associated with resistance to STB, three Quantitative Trait Loci (QTL), viz. *Q.STB.5A.1*, *Q.STB.5B.1*, and *Q.STB.5B.3* were found to have significant phenotypic effects under field evaluations. Furthermore, QTNs located on chromosomes 1A (*Q.STB.1A.1*), 2A (*Q.STB_DH.2A.1*, *Q.STB.2A.3*), 2B (*Q.STB.2B.4*), 5A (*Q.STB.5A.1*, *Q.STB.5A.2*), and 7B (*Q.STB.7B.2*) could potentially be new genetic regions associated with resistance in wheat.

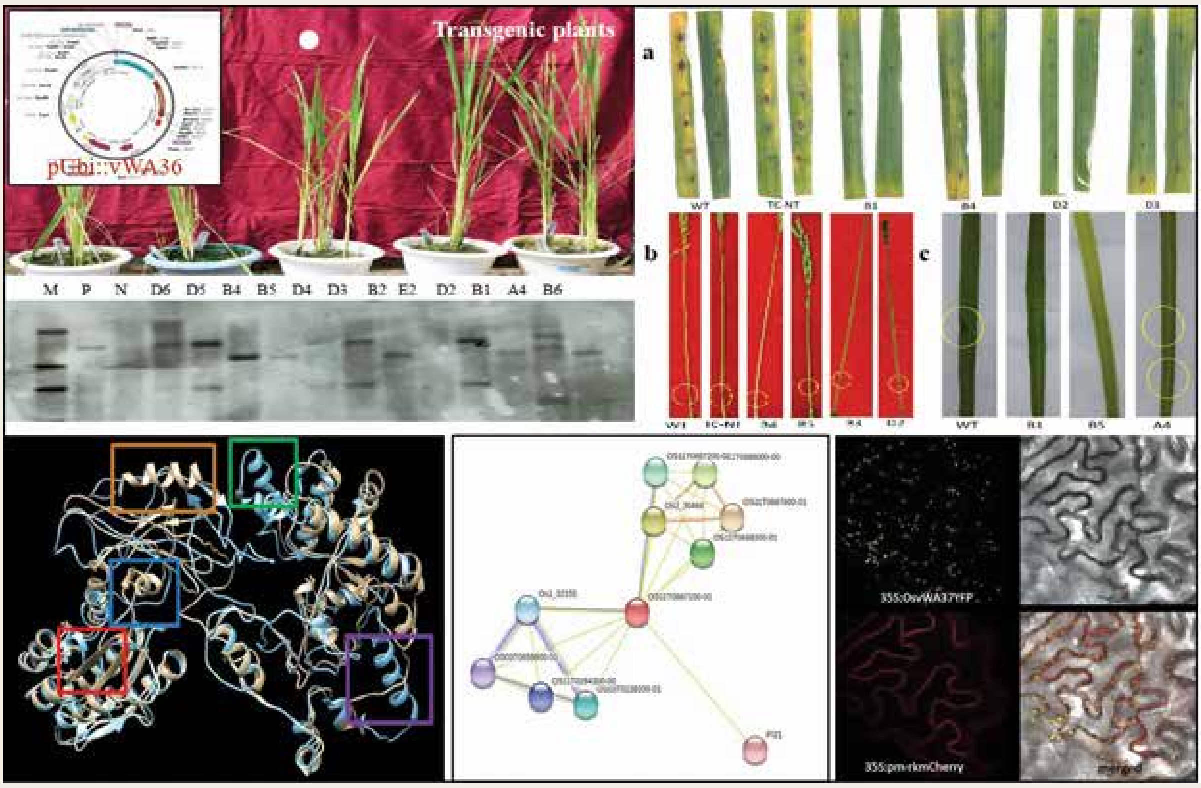
Identification of key genes and molecular pathways regulating heat stress tolerance in pearl millet: To investigate heat-responsive genes, genome-wide transcriptomes of two contrasting pearl millet inbreds, EGTB 1034 (heat tolerant) and EGTB 1091 (heat sensitive), were analyzed under heat-treated conditions. A total of 13,464 differentially expressed genes (DEGs) were identified, including genes encoding ROS scavenging enzymes, WRKY, NAC, heat shock proteins (HSPs), and other transcription factors (TFs) involved in stress-response mechanisms. Comparative synteny analysis revealed higher collinearity of HSPs and TFs with pearl millet than with proso millet, rice, sorghum, or maize. These genes provide valuable insights for accelerating the development of heat-tolerant varieties in pearl millet and related crops.

Novel SNPs linked to blast resistance genes identified in pearl millet: A genome-wide association study (GWAS) on a pearl millet panel phenotyped against three isolates of *Magnaporthe grisea* from Delhi, Gujarat, and Rajasthan revealed significant variability, with 16.7% of inbreds showing high resistance. GWAS models identified 68 significant SNPs linked to resistance, with hotspots on chromosomes 1, 2, and 6. These regions contain genes associated with immune response, stress tolerance, signal transduction, transcription regulation, and pathogen defense. This study provides critical insights into the genetic basis of blast resistance, supporting marker-assisted breeding and gene-editing approaches for developing resistant pearl millet varieties.

Role of functional genes for seed vigour and longevity traits through genome-wide association mapping in finger millet (*Eleusine coracana*): Seed longevity and seedling vigour are crucial for sustainable crop production amid climate change. A significant variation was identified in seedling vigour traits in the GWAS panel. GWAS model from 11,832 high-quality SNPs identified through Genotyping-by-Sequencing (GBS) approach produced 491 marker-trait associations (MTAs) for 27 seed longevity traits. A pleiotropic SNP, FM_SNP_9478 identified on chromosome 7B was associated with the traits GAA, GAAR, and GIAA. Functional annotation revealed *DET1* and *expansin-A2* influenced seed coat integrity, critical for germination and aging resilience. *Beta-amylase* and *acetyl-CoA carboxylase 2* were identified for seed metabolism and

A novel gene *OsvWA36* confers blast resistance in rice

A novel gene, *OsvWA36*, was identified to confer resistance against rice blast disease caused by *Magnaporthe oryzae*, a major pathogen responsible for significant economic losses. Durable, broad-spectrum resistance is crucial for disease resistance breeding, and Von Willebrand factor (VWF) domain A genes were characterized for the first time in rice. Among these, *OsvWA36* and *OsvWA37* were found to regulate blast infection responses, with *OsvWA36* being evolutionarily conserved. *OsvWA36* overexpression in transgenic plants conferred resistance to both leaf and panicle blast. Cellular localization assays revealed its presence in the plasmodesmata, and its interaction with the broad-spectrum resistance gene *Pi21* confirmed its role in enhancing disease resistance. ICAR-National Institute for Plant Biotechnology, New Delhi, has filed a patent for *OsvWA36*.



A. *OsvWA36* overexpressing transgenic plants; B: Blast phenotyping of transgenic plants by detached leaf, in panicle and leaves by spore inoculation assay; C: Superimposed structures of *OsvWA36* from Tetep (R) and Nipponbare (S) with variations at 5 positions including one in vWA domain (red box); D: Functionally associated proteins including Pi21 and NBS-LRR using STRING analysis; E: Cellular localization of OsvWA37-YFP in plasmodesmata using tobacco Agro-infiltration.

stress response. These insights lay the framework for targeted breeding efforts to improve seed quality and resilience under diverse production conditions.

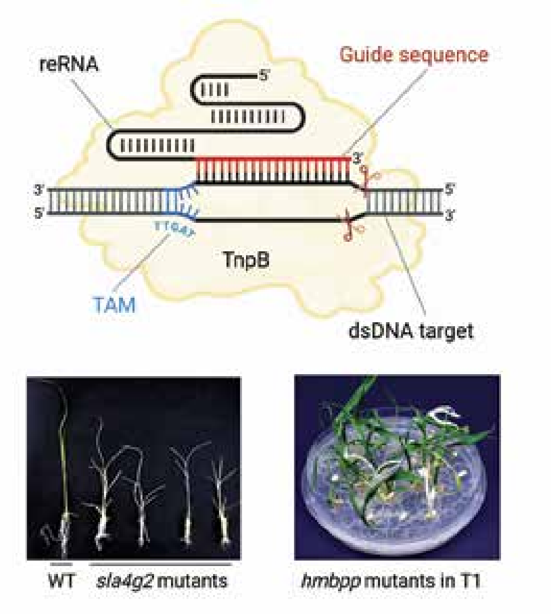
Role of methionine sulfoxide reductase(s) (*CpMSRB1*) in resistance to *Helicoverpa armigera* in pigeonpea: Transcriptome analysis of *Cajanus platycarpus*, a wild relative of pigeonpea, identified *CpMSRB1* as a key gene in redox homeostasis-mediated resistance to *Helicoverpa armigera*. *CpMSRB1* interacts with Chorismate Mutase (CM) to ensure uninterrupted production of secondary metabolites during herbivory. CM facilitates the phenylpropanoid pathway by converting chorismate to prephenate. Transgenic tomato lines expressing *CpMSRB1* showed enhanced protection of methionine residues in CM from oxidative damage, leading to increased synthesis of defense compounds and herbivore deterrence.

Whole genome sequencing of wild relative of pigeonpea for identifying useful genes in the secondary gene pool: *Cajanus scarabaeoides*, a wild relative of cultivated pigeonpea, belongs to the secondary gene pool and is easily crossable. It exhibits valuable agronomic traits such as early flowering, dwarfism, photo-insensitivity, high seed count per pod, heat tolerance, and resistance to biotic stresses. It is also the source of A2 cytoplasm, crucial for male sterility. Using a combination of long-read Nanopore sequencing (47x) and short-read Illumina sequencing (48x), a hybrid genome assembly was developed. The resulting *C. scarabaeoides* genome spans 406.69 Mb, organized into 1,124 scaffolds with an N50 value of 8.54 Mb, offering a valuable resource for trait improvement in pigeonpea.

Telomere-to-Telomere chromosome-scale whole genome sequencing of winged bean: Winged bean *(Psophocarpus tetragonolobus)* is an underutilized diploid legume (2n=2x=18) with high nutritional value, including protein content (34.3%–40.7%) and oil content (16.4%–21.3%). However, genomic resources

TnpB: A compact alternative to Cas9 for plant genome editing

ICAR-NRRI Cuttack developed Transposon-associated TnpB, a compact genome editing tool (one-third the size of Cas9/Cas12a) derived from *Deinococcus radiodurans*, overcoming the size limitations of Cas9 and Cas12a (~1,300 amino acids). Codon-optimized for plant systems, TnpB is only 408 amino acids and demonstrated up to 69% editing efficiency in rice and *Arabidopsis*. ICAR-NRRI also showcased its multiplex editing ability in rice and developed a catalytically inactive version, dTnpB, for transcriptional activation and base editing. Using the dTnpB activator system, targeting promoter regions achieved up to a 10-fold upregulation of downstream genes. This miniature TnpB system holds immense promise for efficient plant genome engineering and gene regulation.

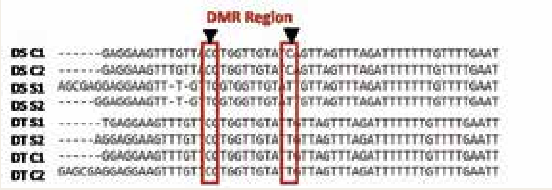


Upper panel: TnpB nuclease with target DNA and reRNA element. The 20-nucleotide guide sequence can be customized to target gene of interest. *Lower panel*: Albino rice plants generated through TnpB-mediated disruption of chlorophyll biosynthetic genes.

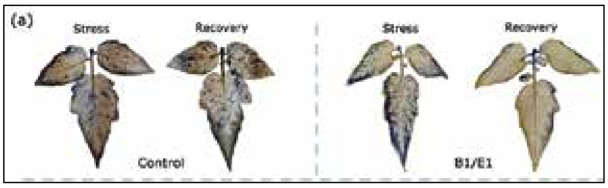
for this crop are limited. Whole genome sequencing at 56X coverage was performed, achieving a complete chromosomal assembly spanning from telomere to telomere. The estimated genome size is 710 Mb, confirmed by flow cytometry. Sequencing was conducted on the PacBio Sequel-II platform, generating 990 Gb of raw data. Hi-C data and Bionano optical mapping were used to scaffold the genome, resulting in a final assembly of 697 Mb organized into 15 scaffolds, with the largest scaffold measuring 111 Mb. The assembly's N50 value was 85.9 Mb, and its N90 value was 41.7 Mb. BUSCO analysis showed 97.61% completeness (C: 94.5%, D: 3.11%). Nine large scaffolds corresponded to individual chromosomes, and telomere analysis revealed that chromosomes 1, 2, 3, 4, 5, and 7 have telomeres at both ends, while chromosomes 6, 8, and 9 lack telomeres at one end. A total of 49,431 genes were predicted from the

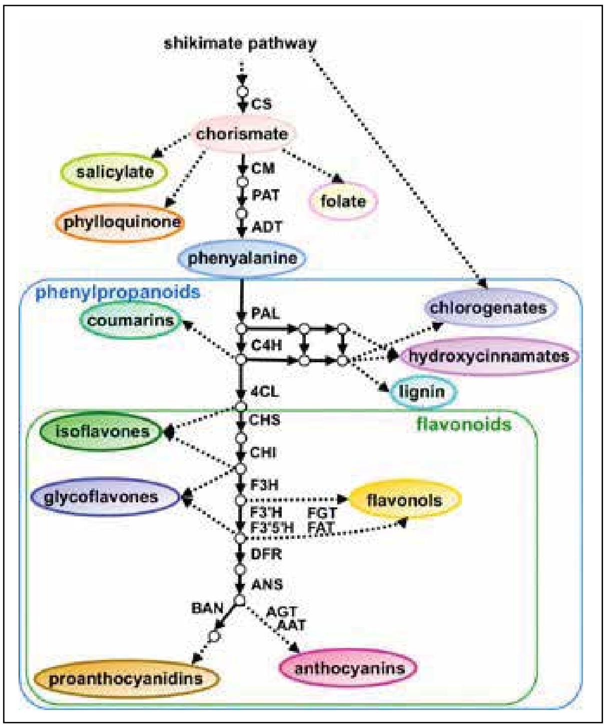
Epigenetic regulation of drought tolerance in chickpea

DNA methylation plays a key role in plant stress responses but is not well studied in chickpea. Methylome sequencing of root tissues from two contrasting chickpea genotypes (ICC4958-drought tolerant and ICC1882-drought sensitive), combined with transcriptome analysis, identified differentially methylated regions (DMRs) and corresponding differentially expressed genes (DMR-DEGs). Key findings include differential methylation of ABC transporter and SPL genes and hypomethylation-linked downregulation of the *RPS6* gene in the drought-sensitive genotype, potentially affecting ribosomal biosynthesis. DMR validation via BS-PCR sequencing confirmed these results. The study sheds light on epigenetic regulation in chickpea's drought response, providing a basis for improved stress-resilient breeding strategies.



Differential methylation (BS-PCR) in chickpea under drought stress

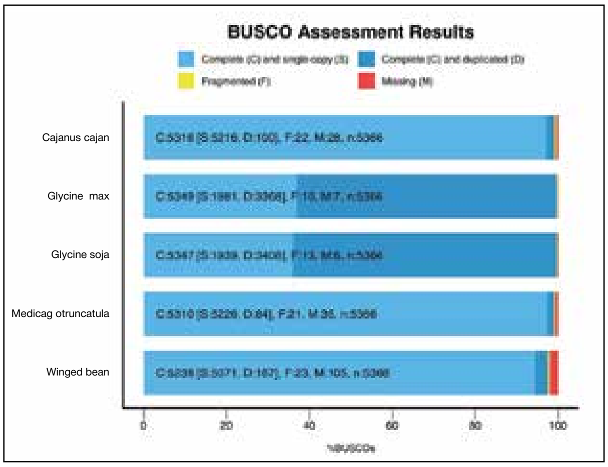




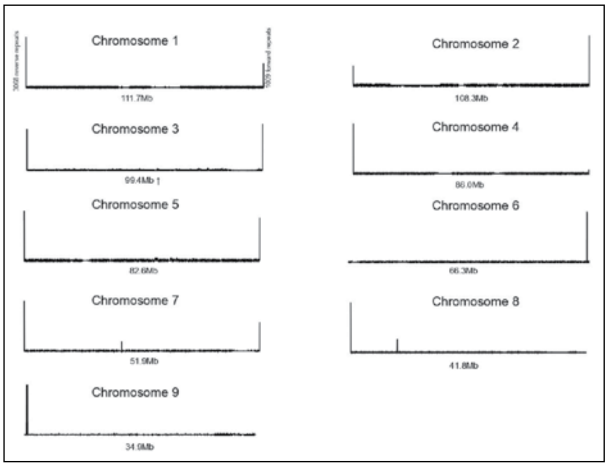
Overexpression of *CpMSRB1* in tomato demonstrated increased total polyphenols and improved ROS scavenging leading to improved efficacy against pod borer *Helicoverpa armigera*

Assembly statistics of winged bean genome

Scaffold (>= 0 bp)	15	N90	41789641bp
Scaffold (>= 1000 bp)	15	NG50	859773384bp
Total scaffold	15	NG90	111651818bp
Largest scaffold	111651818bp	L50	4
Total length	697685870bp	L90	8
Estimated reference length	700	LG50	1
GC (%)	31.08	LG90	1
N50	85977384bp	N's per 100 kbp	27.47



Completeness analysis of the winged bean genome using BUSCO with the Fables database. C; Complete, S; Single copy, D; Duplicate, F; Fragmented, M; Missing, n, Total number of BUSCOs.



Telomere prediction from the assembled chromosomes of the winged bean genome. Vertical lines represent the telomere signals.

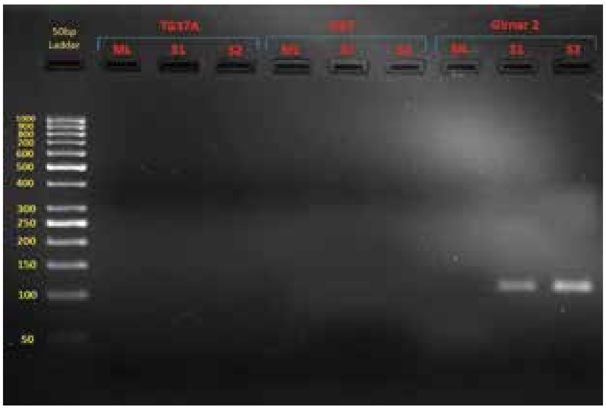
assembled genome.

Identification of the gene for seed coat colour in winged bean: The seed coat colour in winged bean ranges from white to brown to purple, serving as an essential marker for breeding and indicating to the plant's antioxidant properties. Seed coat colour-related QTLs *qSdc1.1* and *qsdc3.1* was analyzed using flanking marker information and a chromosome-level reference genome sequence. Gene prediction from these QTL regions identified 127 genes for qSdc1.1 and 24 for qsdc3. *In-silico* annotation of these genes using the NCBI database highlighted four key seed coat colour with its different paralogous genes: *qSdc1.1-9, qSdc1.1-12, qSdc1.1-15, qSdc1.1-16, qSdc1.1-17, qSdc1.1-18, qSdc1.1-25, qSdc1.1-28* (UDP-glycosyltransferase 83A1), *qSdc1.1-74, qSdc1.1-78, qSdc1.1-79* (Transcription factor MYB113), from QTL *qSdc1.1*. Similarly, from QTL *Qsdc3.1,* the selected genes were *qSdc3.1-3* (G-box-binding factor 4), *qSdc3.1-12, qSdc3.1-13, qSdc3.1-16, qSdc3.1-18* (WAT1-related protein).

Expression analysis of genes in different winged bean genotypes revealed that *qSdc1.1-78* (Transcription factor MYB113) and *qSdc3.1-13* (WAT1-related protein) are upregulated in purple and semi-purple genotypes but not in white seed coloured genotypes. This suggests their role in seed coat colouration. The study provides insights into the genetic basis of seed coat colour and identifies key genes involved in anthocyanin production in the winged bean.

AhRSV–A potential seed-specific biomarker to differentiate Virginia from Spanish groundnut genotypes identified: Raffinose Family Oligosaccharides (RFOs) have vital physiological roles in plants but cause flatulence when present in high amounts in legumes. Balancing RFO reduction while preserving normal plant function requires identifying key regulatory genes in the RFO biosynthetic pathway. A comparative RNA sequencing analysis was performed on contrasting genotypes from Spanish (TG37A and GG7) and Virginia (Girnar 2) groundnut groups for the Raffinose Synthase (RS) gene, designated as AhRSV (AY7U99). RNA-seq data revealed no detectable AhRSV transcript in Spanish varieties, with qPCR analysis showing negligible expression differences between maturing (S1) and mature (S2) seeds in these varieties. However, differential expression was observed between TG37A and GG7 at both S1 and S2 stages, with TG37A seeds (high RFOs) showing minimal expression and GG7 seeds (low RFOs) exhibiting almost negligible expression. Despite this, the gene appears specific to the Virginia group, as evidenced by expression patterns. *AhRSV* demonstrated constitutive expression in Girnar 2, particularly in seeds, with significantly higher expression than Spanish varieties at both seed stages. Additionally, agarose gel electrophoresis showed no band for seed samples from Spanish varieties or leaf samples from all varieties, highlighting AhRSV's potential as a seed-specific biomarker for Virginia groundnut varieties.

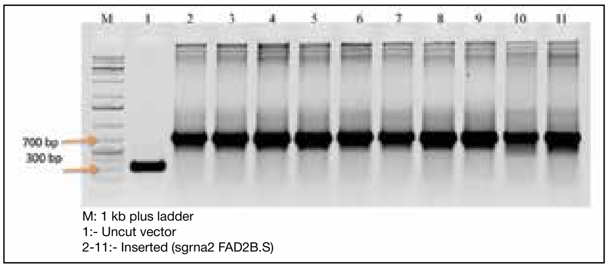
Targeted gene editing for high oleate trait (FAD2 gene) in groundnut using CRISPR/Cas9: Two guide



Peanut Virginia group-specific expression of *AhRSV*. Mature leaf (ML), Maturing (S1) seed, and Matured (S2) seed of genotypes representing the Spanish group (TG 37A and GG 7) do not show any expression while the genotype of the Virginia group (Girnar 2) showed seed-specific expression.

RNAs (gRNA1 and gRNA2) specific to FAD2B were designed and synthesized. MtU6 and scaffold fragments were amplified using their respective primers from pUC gRNA shuttle vector. Four DNAs were mixed together (U6 promoter fragment, gRNA ssDNA, scaffold fragment and Linearized vector) to develop gene editing construct. Positive colonies were screened using PCR for confirmation. The obtained plasmid (10 colonies for each gRNA) was sent to sequencing after PCR confirmation. The sequencing results obtained were analyzed and confirmed for the presence of the guide RNA1 and guide RNA 2. Confirmed construct were mobilized in *Agrobacterium tumefaciens* for attempting genetic transformation experiments. Competent *Agrobacterium* strain LBA 4404 cells were transformed with the gene editing construct. Transformed cells were selected on kanamycin and rifampicin plates. PCR was used to verify successful transformation (700 bp band). The mature seeds of the variety GG 20 were used in the study (Oleic acid-63.93%, Linoleic acid-19.68% and Mutation in FAD2A is present). The de-embryonated cotyledons explants from mature pre-soaked seeds were co-cultivated with *A. tumefaciens* strain LBA4404 harbouring the CRISPR/Cas9 plasmid. A total of 328 plantlets were regenerated.

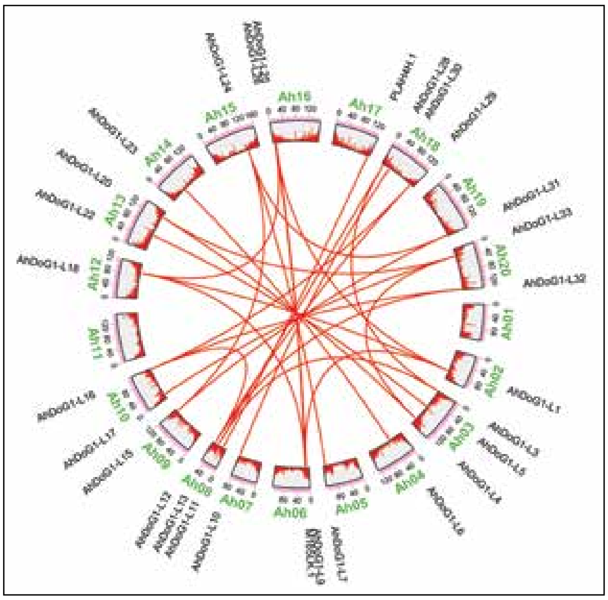
Identification and GA-mediated regulation of the delay of germination (*DoG1*) genes during seed dormancy in groundnut: A comprehensive analysis of the *DoG1*-like (*AhDoG1L*) gene family in groundnut was done. Using a groundnut-specific Hidden Markov Model, 34 *AhDoG1L* genes were identified, all containing the conserved DOG1 domain, with some members also exhibiting a bZIP domain. Phylogenetic analysis categorized these genes into three distinct subclades, indicating functional diversification. The genes are dispersed across the groundnut genome, predominantly at terminal positions, suggesting potential roles in gene regulation. Synteny and orthologous gene comparisons with soybean and sunflower *DoG1* genes demonstrated conserved functions and evolutionary relationships.



PCR amplification of insert (gRNA 2)

Promoter analysis identified 10 conserved motifs and cis-acting regulatory elements (CAREs) responsive to environmental factors like low temperature, hormones, and light. Protein-protein interaction networks highlighted the coordinated role of *DoG1* genes in seed dormancy regulation, supported by GO term enrichment analysis implicating them in transcriptional regulation and DNA binding. Quantitative RT-PCR revealed differential expression of 11 *AhDoG1* genes in freshly harvested and germinated seeds of the TG 37A genotype, suggesting their role in seed dormancy. Gibberellic acid (GA) treatment further identified *AhDoG1-L34*, *AhDoG1-L30*, and *AhDoG1-L22* as GA-responsive genes in PBS 15014, underscoring their involvement in regulating seed dormancy through GA-mediated pathways.

Expression of Sodium Hydrogen Exchanger (NHX) gene family members in *Vigna mungo* under salt stress: The NHX gene family is crucial for the maintenance of cellular pH and ion homeostasis, which is necessary for the growth and development of cells. The identification and characterization of NHX genes are made possible by the availability of genome sequences for multiple *Vigna* species. These genes may be employed in future breeding and genetic engineering initiatives that are designed to create salt-tolerant cultivars. A comprehensive investigation was conducted to identify and describe the NHX gene family in *Vigna*



Distribution of *AhDoG1* gene family in groundnut *mungo* in order to gain a genomic understanding of the NHX genes that regulate salt tolerance in *Vigna* species. In *Vigna mungo,* 44 members of the NHX gene family were identified. The domains, evolutionary relationships, and gene architecture of these genes were used to classify them into two categories. Clade I was the designation for intron-poor genes, while clade II was the designation for intron-rich genes. A convergent evolution of NHX genes was suggested by the comparison of the *V. marina* NHX genes with those of cultivated species. The mechanism of salt resistance in blackgram has been clarified through gene profiling, ion partitioning, and biochemical investigations. The data suggests that salinity tolerance is associated with the expression patterns of five Vm_NHX genes (Vm_NHX16, Vm_NHX17, Vm_NHX29, Vm_NHX30, and Vm_NHX33). It is important to note that all of these, with the exception of Vm_NHX30, were located in the lysosomal and vacuolar membranes.

***In-vitro* regeneration in *Vigna radiata* via direct organogenesis:** *In-vitro* multiple shoot regeneration system in mungbean *via* organogenesis has been developed using double cotyledonary node (DCN) and detached embryonic axis (EA) explants with 1.0 mg l-1 BAP. While both the explants respond to *in-vitro* regeneration, number of shoots regenerated is higher with EA than with DCN. 6-benzyl aminopurine (BAP) was found to be most effective for inducing and regenerating multiple shoots, in comparison to all other phytohormones (NAA, IAA and TDZ) and supplements (glutamine, proline, and cysteine) tested. Subculturing twice on BAP supplemented media followed by two subcultures on basal media was optimal for multiple shoot regeneration. Rhizogenesis was obtained on basal media devoid of any phytohormones in EA explants and in 1.0 mg l-1 IAA for DCN explants. Basal media used in experiments was MSB5 with pH 5.8 ± 0.02 before autoclaving (121 °C and 1.2 kg cm^{-2} for 15 min). Cultures were established at 25 ± 2 °C under a 16:8 h (light, dark) photoperiod with light intensity 25 µmol m^{-2} s^{-1} photosynthetic photon flux density (PPFD) provided by cool white fluorescent tube lights. The *in-vitro* regenerated plantlets were successfully hardened in a mixture of soil, sand and vermiculite that flowered, produced pods and gave viable seeds on maturity. The Embryonic axis was found as a better responding explant that gave higher shoot number per explant in comparison to the cotyledonary node with 1.0 mg l-1 BAP. An increased regenerative capacity of EA explants by adventitious shoot formation, its subsequent elongation and rhizogenesis was demonstrated.

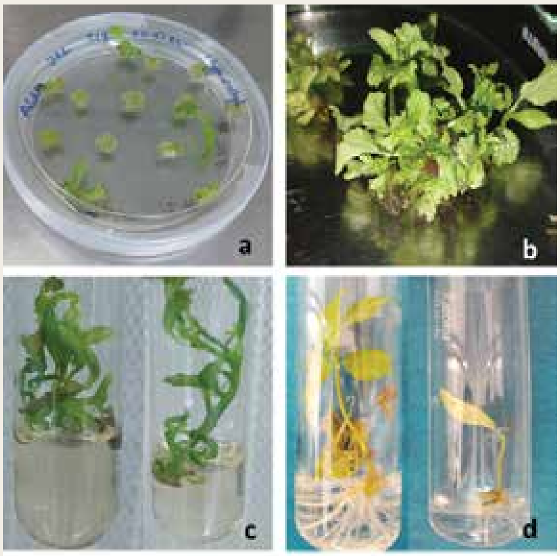
In-vitro regeneration of *vigna radiata*

Biotechnological interventions in insects and microbes management

RNAi-mediated targeting of chitin synthesis genes for cotton pink bollworm (PBW) management: Chitin is the major structural polysaccharide present in insect exoskeleton and gut lining. The chitin synthesis genes *PgAGM* and *PgUAP* were targeted by RNAi in PBW, resulting in detrimental effects on insect growth

Genome editing for improved jute varieties

The fiber of *Corchorus olitorius*, or tossa jute, contains a high lignin concentration (15–22%), limiting its use in industries like textiles, paper pulp, and biofuels. To address this, CRISPR/Cas-based genome editing is being employed to develop jute varieties with reduced lignin in bast fibers, improving fiber quality for textiles and other applications. Lower pectin levels in jute bark will also speed up and lower the cost of the retting process. Key genes regulating flowering behaviour and herbicide tolerance have been identified for SDN1-mediated editing. These improvements could enable early sowing to avoid unfavourable climate conditions and make jute more resistant to broad-spectrum herbicides, reducing cultivation costs. The "Enhancing Climate Resilience and Ensuring Food Security with Genome Editing Tools", focuses on gene selection, gRNA design, cloning, and initial molecular analyses. Future steps include field trials and commercialization.



In-vitro regeneration system in jute. a) Adventitious shoot bud initiation from explants in regeneration medium; b) multiple shoot regeneration; c) elongated shoots from hypocotyl and cotyledonary leave derived explants; d) robust root induction in rooting medium.

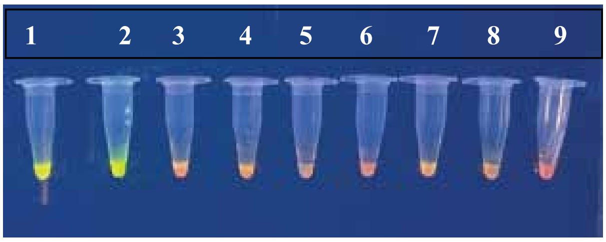
and development. The RNAi-mediated gene silencing of *PgAGM* and *PgUAP* led to approximately 30% and 40% mortality rates in PBW respectively. Additionally, various detrimental phenotypes were observed, including molting defects (e.g. larva-pupa, larva-larva, half pupa-half adult), poor growth, and significant weight loss. These results functionally validate the roles of *PgAGM* and *PgUAP* in PBW growth and development, confirming their potential as targets for RNAi-based pest management strategies.

Structural diversity and functional potential of *Streptomyces* spp. inhabiting Pachmarhi Biosphere Reserve, an unexplored habitat of India: A study was undertaken to investigate the genetic and functional diversity of *Streptomyces* species isolated from the Pachmarhi Biosphere Reserve (PBR), a previously unexplored site in India. Through 16S rRNA gene sequencing, 96 isolates were identified, representing 40 different species, revealing a substantial phylogenetic diversity. The isolates were grouped into two major clusters, demonstrating intraspecies diversity and interspecies closeness. Genetic diversity was further analyzed using BOX-PCR, which confirmed a wide range of variability among the strains. Functional analysis revealed that a significant number of strains exhibited enzymatic activity, with 53, 42, 41, 11, and 54 strains testing positive for CMCase, xylanase, amylase, pectinase, and β-glucosidase, respectively. Additionally, 54 strains demonstrated polyhydroxybutyrate (PHB) production. Quantitative assays identified specific strains exhibiting maximum enzymatic activities: *Streptomyces* sp. MP9-2 for CMCase (0.604 U/mL), *Streptomyces* sp. MP10-11 for xylanase (0.553 U/mL), *Streptomyces* sp. MP10-18 for amylase (1.714 U/mL), and *Streptomyces* sp. MP10-6 for pectinase (13.15 U/mL). Several strains were also found to possess plant growth-promoting traits, such as zinc and phosphate solubilization, ammonia and hydrogen cyanide (HCN) production, nitrogen fixation, and the production of indole acetic acid (IAA). In addition, 50 strains showed antifungal activity against *Fusarium oxysporum* f. sp. *lycopersici*, with inhibition rates ranging from 7.5% to 47.5%. These findings highlight the potential ecological and biotechnological applications of *Streptomyces* spp. isolated from the PBR, particularly in the areas of enzyme production, plant growth promotion, and biocontrol.

Molecular characterization of mealybug species: The CYPome and Halloween gene family of *Maconellicoccus hirsutus* has been identified, characterized, classified. RNAi machinery genes of *M. hirsutus* were identified, characterized and the analysis on the expression upon dsRNA induction proved the presence of robust RNAi pathway in *M. hirsutus*. Transcriptome of cassava mealybug *Phenacoccus manihoti* was sequenced and important gene families and pathways have been identified for the first time in the world.

Investigations on mating-induced transcriptional changes in female moths of fall armyworm (*Spodoptera frugiperda*): Post-mating transcriptional changes in fall armyworm revealed that 13,207 differentially expressed transcripts were identified, with 846 transcripts exhibiting significant expression 24 h post-mating with 89 upregulated and 757 down regulated genes. Key upregulated genes included cathepsin B, cytochrome P450 6B1, ecdysone oxidase, ribosome-binding protein-1, which play essential role in egg development, detoxification, hormone synthesis, and protein production that are critical for successful reproduction. Conversely, genes related to the immune system, such as serine-protease inhibitor dipetalogastin-like, attacin, lysozyme, were downregulated. This suggests a strategic trade-off between allocating resources for successful reproduction and maintaining an effective immune defense.

Development of recombinase polymerase amplification-based colorimetric detection assay for rapid identification of invasive cassava mealybug: Cassava mealybug, *Phenacoccus manihoti*, is an invasive pest responsible for huge devastation of cassava. Morphological identification of this pest is very difficult as it needs expertise and is also time-consuming. Detection of such invasive pest at an early stage is necessary. Hence, rapid, specific, sensitive, promising, isothermal detection assay was developed which can eliminate the requirement of costly equipments and is also time-saving. Due to its high sensitivity and rapidity, it has applications in quarantine stations.



RPA amplification of *P. manihoti* and other mealybug species. Lane 1 to 2 – *Phenacoccus manihoti* collected from 2 different regions; Lane – 3 *Planococcus citri*; Lane 4 – *Pseudococcus longispinus*; Lane 5 – *Pseudococcus jackbeardsleyi*; Lane 6 – *Phenacoccus solenopsis*; Lane 7 – *Maconellicoccus hirsutus*; Lane 8 - *Ferrssia virgata*, Lane 9 – Non-template control.

HORTICULTURAL CROPS

Release and notification of varieties

A total of 189 varieties in 75 crops were identified by the Central Sub-Committee on Crop Standard, Release and Notification of Varieties of Horticultural Crops, Government of India as detailed here.

Biotechnology

Embryo rescue in grapes: Protocols were standardized for the development of hybrid progeny through embryo rescue involving seedless parents (Flame Seedless and Crimson Seedless) and a seeded parent (Red Globe). A total of 78 F_1 hybrids were developed from the combinations Red Globe × Flame Seedless

Crops	Name of the Varieties
Fruit and nut crops	
Mango	Sunderja Selection-2, Gujarat Mango 1 (Anand Rasraj), Cardozo Mankurad, Arka Udaya, Arka Suprabhath, Ambika H-558 (CISH M-1), Arunika (H-39)
Guava	GARFG-1: Lal Bahadur, Arka Poorna, Arka Rashmi (IIHR-H 3-29), Lalit (CISH G-3), Shweta (CISH G-4), Dhareedar
Tamarind	Shiwai, KPT (Krishna Prabha Tamarind)
Jackfruit	Byrachandra, GKVK Red Jack, Lalbagh Madhura, PKM 1 (AH-15), Jackfruit PKM 2 (IC No. – 0638824)
Bael	Swarna Vasudha, Narendra Bael-8 (ND-AH-8), Narendra Bael- 10 (ND-AH-10), Narendra Bael-11 (ND-AH-17)
Walnut	Parbat (JWSP-06), Shalimar Walnut-001 (SKUA-W-001), Shalimar Walnut-002 (SKUA-W-002)
Pomegranate	Solapur Lal (NRCPH-6), Solapur Anardana (NRCPH-12)
Jamun	Jamun PKM 1 (SC-04)
Aonla	Narendra Aonla-25, Narendra Aonla-26
Banana	Banana CO 3, Gujarat Banana 1 (GB 1: Anand Vaaman)
Pummelo*	Arka Anantha (Clone 25-5), Arka Chandra (Clone 18-5)
Custard apple	Arka Sahan
Cashew	Goa Cashew-5 (Tudal-1), Goa Cashew-6 (H-21/05), Nethra Ubhaya, Nethra Jumbo-1 (H-126), Nethra Ganga (Hybrid H-130)
Plantation crops	
Coconut	Kalpa Shatabdi (IND 034S), Dweep Haritha, Dweep Sona, Kalpa Suvarna
Cocoa	VTLCH-1 (Vittal Cocoa Hybrid-1), VTLCH-2 (Vittal Cocoa Hybrid-2)
Vegetable crops	
Brinjal	OUAT Kalinga Brinjal 1 (Banita) (BB-67), NDB White-1 (Narendra Suyog), PBHL-56 (Long Fruit Group), PBSR-9322, Shalimar Brinjal Hybrid-3, OUAT Kalinga Brinjal 1 (Banita) (BB-67), AKLB-9, RC Manikhamen-1, Gujarat Green Brinjal 9 (Anand Harit), Sabour Krishnakali (BRBL-07), Sabour Sadabahar (BRBL-01), OUAT Kalinga Brinjal - 2 (Abhishek), Pusa Chhota Baingan 1 (DBOR-94)
Tomato	Pusa Shakti (DT-19), Pusa Tomato Hybrid-6, TH-1214, RFT-S-1 (Krishna Prabha Shaant), OUAT Kalinga Tomato 1 (Gouri) (BT-2016), OUAT Kalinga Tomato-2 (Nirmala), MABC-2 (Krishna Prabha Tunga), Krishna Prabha Baari, Krishna Prabha Shalmala (MABC-1), Pusa Cherry Tomato Hybrid-1, PBNT-20
Capsicum	Apporva (CP-40)
Drumstick	Bhagya (KDM-01)
Chilli	UARChH-42 (Ruby Deep), Shalimar Kashmiri Chilli-1, Gujarat Vegetable Chilli 113 (GVC 113: Anand Jwala), OUAT Kalinga Chilli 1 (Ragini) (BC-2016), Krishna Prabha Rudra, Krishna Prabha Shuka (SRS-2), UARCH 43 (Vitthal), OUAT Kalinga Chilli - 2 (Gagan), PBNC-17
Bottle gourd	Kashi Shubhara (VRBG-14), NDBGH-14-10 (Narendra Sita), NDBG-16 (Narendra Kamna)
Pumpkin	PPH-1
Ridge gourd	Rajni (VNR 103), Arka Prasan
Bitter gourd	Pusa Protected Bitter Gourd-2 (DBGS-32-1)
Carrot	Krishna Prabha Vriddhi, Solan Shreshth
Kachri*	Thar Kasturi (Kachri AHK-119)
Sponge gourd	VNR Anita, Ken Swadisht (BUAT SG 18-1)
Watermelon	Thar Tripti
Mateera (Water melon)	Thar Madhur (Mateera AHW-19), Thar Manak (Mateera F6/a)
Melon	Gujarat Melon 2 (GM 2: Anand Sheetal)
Muskmelon	Thar Mahima (AHMM/BR-47)
Snap Melon	Snap melon AHS-82
Cucumber	Punjab Kheera Hybrid-11 (PKH-11)
Okra	AOL 12-52 Gujarat Anand Okra 7 (GAO 7), Gujarat Okra Hybrid 205 (GOH 205: Anand Kranti), Arka Nikita (F_1) (OKMSH-3), Punjab Lalima (PROL-1), Gujarat Ornamental Okra Hybrid-1 (Anand Shobha) (DHOO-23)
Amaranthus	OUAT Kalinga Amaranthus -1 (Mayuri)
Khejri*	Thar Shobha
Indian bean/sem or Dolichos bean	Kashi Bounisem-207 (VRBSem-207), CO 15 lablab, Arka Krishna (IIHR-15-7), Arka Vistar (IIHR-15-23), OUAT Kalinga Dolichos bean 1 (Jaykrushna) (BDB-2017)
Cluster bean	Krishna Prabha Sangama (COHBCBC-35-S2), Phule Guar (RHRCB Sel. 10)
French bean	Arka Arjun, Lakshmi
Winged bean	Birsa Kamrenga-1 (RWB-13)
Vegetable soybean	Krishna Prabha Pinakini (Cohbsbm-26)
Radish	Him Palam Mooli-1 (DPR-1), UHF R-12-1
Onion	Krishna Prabha Chitravathi
Garlic	Gujarat Garlic-8 (Sorath Mohini) (GG-8), Sabour Garlic-1(BRG-14)
Mustard	Narendra Sarso Sag-1
Perennial moringa*	PKM MO 65 (PKM-3)
Potato and other tropical tuber crops	
Potato	Kufri Chipsona-5, Kufri Bhaskar, Kufri Sukhyati (CP 4631), Kufri Jamunia (MSP/16-307)
Arrowroot*	Sree Nakshathra (TAr 18-12), Sree Karti (TAr 18-14)
Sweet Potato	Rajendra Sakarkand-7 (RS-7) (TSp 12-6)
Yam bean	Rajendra Mishrikand-3 (RM-3) (TYb 14-9) (DPH-6)
Arvi/Taro	Rajendra Arvi-2 (RA-2) (TCbl 12-4)
Elephant foot yam	Elephant Foot Yam CO 1

Crops	Name of the Varieties
Tannia*	G. Tannia-1 (Navsari Pari) (NT-1)
Perennial spices	
Turmeric	Chhattisgarh Haldi-2 (IT 10), Narendra Haldi-4, PDKV-Waigaon (GDT-06-02), OUAT Kalinga Turmeric 1(Surangi) (PTS-59), OUAT Kalinga Turmeric 2 (GOURAB) (PTS-55)
Cassia (Cinnamomum)	IISR Cassia (Konkan cassia)
Black pepper	IISR Girimunda (HP-105), IISR Malabar Excel (HP-813), IISR Thevam (Coll. 1041)
Nutmeg	Konkan Sanyukta (DBSKKVMF 9772), Kerala Shree (Acc No. A9- 69), Goa Jayphal-1 (Tamsuli-1), Goa Jayphal-2 (NMD-2)
Ginger	OUAT Kalinga Ginger 1 (Subhada) (V1E8-2), OUAT Kalinga Ginger 2 (Sourabh) (V1S1-2), OUAT Kalinga Ginger 3 (Prayag) (PGS-121)
Mango ginger	IISR Amrit
Cinnamon	Goa Dalchini-1 (GT-C-3)
Small cardamom	IISR Kaveri, IISR Manushree
Seed spices	
Fennel	RF-290 (UF-290), RF- 289 (Karan Saunf-I) (UF- 289)
Ajwain	Gujarat Ajwain 3 (GA 3)
Coriander	CO 5, Gujarat Coriander 4 (Sorath Sugandha), Krishnaprabha Varadevi 2 (DCC-81)
Fenugreek	Krishnaprabha Devimenthi (DFC-21), GM-4 (Supriya) (NFG-202)
Flowers and other ornamental crops	
Crossandra	Arka Shravya
Tuberose	Arka Prajwal, Arka Vaibhav, Bidhan Ujjwal (Bidhan Rajani-2 (BR-2), Bidhan Singdha (Bidhan Rajani-1 (BR-1)), Phule Rajat (GK-T-D-1)
Gladiolus	Arka Amar (IIHRG-10 or IIHR- 87-22-1), Arka Pratham (IIHRG-12), Arka Kesar (IIHR 86-17-6), Arka Aayush (IIHRG-11), Arka Naveen (IIHRG-5), Punjab Glad-2
Aster	AAC-1 (Krishna Prabha Chinmaya)
Marigold	Pusa Bahar
Rose*	Arka Savi
Adenium*	GNAd-3 (Aabha), GNAd-4 (Shobhita)
Medicinal and aromatic plants	
Velvet bean*	Arka Dhanvantari, Arka Daksha
Mandukaparni*	Arka Prabhavi (IIHR CA 13), Arka Divya (IIHR CA-1)
Stevia*	GKVK Stevia-1
Ashwagandha*	Arka Ashwagandha (IIHR WS 3)

** Subject to Seed Certification Standards*

and Red Globe × Thompson Seedless. Additionally, 365 F_1 hybrids were obtained from crosses including Red Globe × Fantasy Seedless, Madhu Angoor × Fantasy Seedless, and Christmas Rose × Fantasy Seedless. All these hybrids were successfully transferred to the field.

Genome-wide association analysis (GWAS) was performed using single nucleotide polymorphism (SNP) data and three years of phenotyping data for traits such as berry length, berry diameter, berry weight, and bunch length in 122 grape genotypes. The analysis identified 13 significant SNPs for bunch length and 9 SNPs for berry length. Furthermore, 18 markers were significantly associated with berry diameter. In total, 21 genes linked to bunch length, 28 genes related to berry length, 22 genes associated with berry diameter, and 25 genes influencing berry weight were identified.

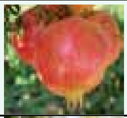
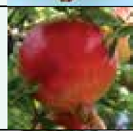
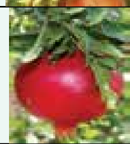
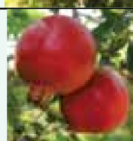
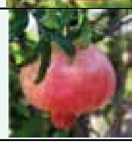
Association mapping in apple using SSR markers: Fifty-eight apple genotypes were evaluated for nine fruit traits and characterized at the molecular level using 53 SSR markers for diversity analysis. Population structure analysis, performed using the 'Evanno method', revealed the presence of two distinct sub-populations within the diversity panel. Association analysis conducted using three different statistical models identified three significant marker-trait associations. The SSR marker GD6 consistently showed a significant association with the fruit length.

Development of 245 InDel markers in relation to growth and development in pomegranate: A total of 140 genes from seven key pomegranate gene families involved in growth and development—*SWEET* (20 genes), *SUS* (5), *SUT* (10), *TALE* (17), *YABBY* (6), *ARF* (17), and *PgbZIP* (65)—were retrieved for marker design. Multiple sequence alignment of these genes across four pomegranate genomes revealed numerous structural variants, including SNPs and InDels. Regions with InDel variations exceeding 8 bp were identified as consensus regions for primer design. As a result, 245 InDel primers were designed, with the *SWEET* gene family contributing the highest number of primers (61), followed by *PgbZIP* (56), *SUT* (36), and *TALE* (37). The *YABBY* gene family had the lowest number of designed primers (13), followed by *SUS* (16) and *ARF* (26).

Construction of DNA barcode: Varietal specific barcodes as developed based on eight hyper variable SSR markers are furnished in table.

Tissue culture of coconut: Significant progress has been made in enhancing callus induction, embryogenic calli formation and somatic embryo development in coconut tissue culture through the utilization of novel growth regulators. Y3 with 2, 4-D (1 mg/L) was identified as most suitable for culture initiation in immature inflorescence explants. Optimal shoot regeneration in explants have been obtained from 5-10 cm and 10.5-15 cm long inflorescences. Increased vegetative buds during culture initiation have been found using Woody Plant Medium supplemented with TDZ (5 mg/L), alone or combined with NAA. In the embryo rescue of sweet

Variety-specific barcodes developed based on eight hyper variable SSR markers

SI.No	Variety	Marker code	Barcode	Fruit morphology
1	Ganesh	11112112	11112112	
2	Mridula	12112121	12112121	
3	Arakta	12112222	12112222	
4	Ruby	12212231	12212231	
5	Super Bhagawa	12122232	12122232	
6	Dholka	12212132	12212132	
7	Kandhari	12112332	12112332	
8	Solapur Lal	22212322	22212322	
9	Jallore Seedless	12121212	12121212	
10	Jyoti	0 2122232	02122232	
11	Bhagawa	22122231	22122231	
12	Yercaud -I	12111212	12111212	

kernel genotypes, approximately 30 plantlets have been potted and 60 plantlets are in the final stage of *in-vitro* culture.

Identification of a CAPS Marker for oil palm fruit type differentiation: A cleaved amplified polymorphic site (CAPS) marker was identified for distinguishing oil palm fruit types. This marker produced two alleles (280 and 250) in dura genotypes, three alleles (550, 280, and 250) in *tenera* genotypes, and a single allele (550 bp) in *pisifera* genotypes. Sequencing of the shell allele revealed two SNPs, with SNP2 contributing to the variation in fruit forms. The nucleotide 'A' was found exclusively in *dura* genotypes, while 'T' was present only in *pisifera* genotypes, resulting in an amino acid change from lysine to asparagine.

The CAPS marker developed in this study enables the early selection and distribution of high-yielding tenera sprouts to farmers, eliminating the need to wait

4–5 years for phenotypic evaluation. This advancement significantly reduces land, time, and financial resources, representing a major breakthrough for the oil palm industry.

***In-vitro* micro-propagation protocol of date palm cv. Barhee**: The *in-vitro* micropropagation protocol for date palm (*Phoenix dactylifera*) cv. Barhee has been successfully standardized. Mature bipolar somatic embryos were inoculated vertically on a plant conversion medium enriched with TDZ + NAA (0.5 + 0.2 mg/L) and TDZ + BA + NAA (0.3 + 0.1 + 0.2 mg/L), both of which effectively facilitated the conversion of somatic embryos into plantlets. These hormonal combinations showed superior performance in terms of plant height, number of leaves, root count, and root length per plant. Currently, the tissue culture laboratory of ICAR-CIAH, Bikaner has 196 plantlets of date palm cv. Barhee with both roots and shoots, 118 plantlets with well-developed shoots, 511 germinated somatic embryos with one or two leaves, 201 PEMC with mono or bipolar structures, about 1,500 flasks containing somatic embryos, and approximately 2,500 flasks with callus cultures being maintained and periodically sub-cultured to generate date palm plantlets regularly.

Tissue culture of cauliflower: Standardized tissue culture based micropropagation protocol for heat tolerant cauliflower genotype VRCF 75-1. The VRCH 75-1 cauliflower genotype produces good quality curds in summer but fails to produce seeds. Therefore, micropropagation from curd florets helps to produce multiple seedlings from a single curd that can be grown in subsequent season.

DNA barcoding of Woody pepper (*Piper pendulispicum*)-Andaman's Local Choi Jhaal, revealed as new species for Indian Flora: The DNA barcoding approach with two plastid barcode markers (ribulose-1, 5-bisphosphate carboxylase/oxygenase large sub-unit-rbcL gene and psbA-trnH spacer region) revealed that the correct botanical identity of the woody pepper is *Piper pendulispicum*. This species has not been reported from the Andaman and Nicobar Islands or any parts of mainland India so far.

Marker free late blight-resistant transgenic potato line KJ 66: The Mendelian segregation pattern of RB event SP951 in Kufri Jyoti progenies revealed marker and plasmid backbone-free KJ 66 line in the Kufri Jyoti background.

Targeted editing of potato genome for developing variety-specific true potato seed (TPS): A targeted genome editing approach was employed to develop variety-specific True Potato Seeds (TPS) in potatoes. A total of 32 putative transformant MiMe lines were generated, with mutations observed in key genes. Among these, 16 lines displayed mutations or editing outside the target area of the *StOSD* gene, seven lines had mutations in the *StREC8* gene, and one line exhibited modifications in the *StSP011* gene.

In another set of experiments, 45 *CENH3*-edited lines were developed, and 35% of these showed target-specific mutations, including insertions and deletions. From these, 14 independent *CENH3* mutation events were selected for crossing with control Kufri Jyoti plants to evaluate haploid induction efficiency. The resulting TPS were germinated and assessed for haploid induction efficiency using flow cytometry.

The haploid induction efficiency in *CENH3*-edited lines ranged from 5% to 15.7%. Cytological analyses of the TPS obtained from hybrids of *CENH3*-edited lines with wild-type Kufri Jyoti plants confirmed haploid induction, with a chromosome number of 2n=2x=12.

Genomic loci governing late blight and potato cyst nematode resistance in potato *(Solanum tuberosum)*: A genome-wide association study (GWAS) was conducted to identify genomic loci regulating resistance to late blight and potato cyst nematodes (PCN), *Globodera pallida* and *G. rostochiensis*, in *Solanum tuberosum*. A panel of 222 diverse potato accessions was evaluated, with phenotype data collected over three consecutive years for late blight resistance and two years for PCN resistance. Genotyping-by-sequencing (GBS) revealed 1,20,622 SNP markers. GWAS, performed using additive and simplex dominance models, identified seven significant SNPs associated with late blight resistance, nine SNPs linked to *G. pallida* resistance, and 11 SNPs associated with *G. rostochiensis* resistance. These SNP associations were distributed across the genome, with notable clustering on chromosomes 5, 10, and 11– regions previously identified as hotspots for disease-resistance genes.

Somatic embryogenesis

Germinated somatic embryo

In-vitro plant formation

PM releases 109 high-yielding, climate-resilient and biofortified varieties of crops

Prime Minister Shri Narendra Modi released 109 high-yielding, climate-resilient and biofortified varieties of crops developed by ICAR at India Agricultural Research Institute, New Delhi on 11 August 2024. He also interacted with the farmers and scientists on the occasion. Discussing the importance of these new crop varieties, Prime Minister stressed on the significance of value-addition in agriculture. The farmers said that these new varieties will be highly beneficial as they will help to reduce their expenditure, combat malnutrition and will help in dealing with the environmental issues.

Prime Minister discussed the importance of millets and underlined how people are moving towards nutritious food. He also talked about the benefits of natural farming and the increasing faith of common people towards organic farming, adding that people have started consuming and demanding organic foods. The farmers appreciated the efforts undertaken by the government for promoting natural farming.

The farmers acknowledged the role played by Krishi Vigyan Kendras (KVK) in creating awareness. Prime Minister suggested that KVKs should proactively inform farmers about the benefits of the new varieties being developed every month.

Prime Minister also applauded the scientists for the development of these new crop varieties. The scientists informed that they have been working in line with the suggestion given by Prime Minister to bring under-utilized crops into the mainstream.

The 109 varieties of 61 crops released by the Prime Minister included 34 field crops and 27 horticultural crops. Among the field crops, seeds of various cereals including millets, forage crops, oilseeds, pulses, sugarcane, cotton, fibre and other potential crops were released. Among the horticultural crops, different varieties of fruits, vegetable crops, plantation crops, tuber crops, spices, flowers and medicinal crops were released.

Glimpses of the Varieties Released

Wheat – Pusa Gehun Sharbati (HI 1665)

Maize – Pusa Popcorn Hybrid – 1 (APCH 2)

Maize-Pusa HM4 Male Sterile Baby Corn-2 (ABSH4-2)

Pearl millet-Pusa 1801 (MH 2417)

Mung Bean-PMS-8

Tomato-Pusa Shakti

Marigold-Pusa Bahar

Cotton-CICR-H Bt Cotton 40 (ICAR-CICR-PKV 081 Bt)

Safflower-ISF-300

Glimpses of the Varieties Released


Groundnut – ICAR KONARK (Spanish Bunch)


Rice – DRR Dhan 73 (IET 30242)


Pigeonpea-NAAM-88

Mungbean-Lam Pesara 610 (LGG 610)


Pummelo – Arka Chandra


Mandukaparni – Arka Prabhavi

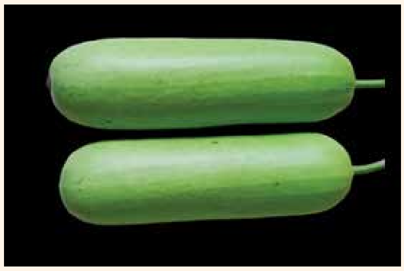

Mango – Ambika

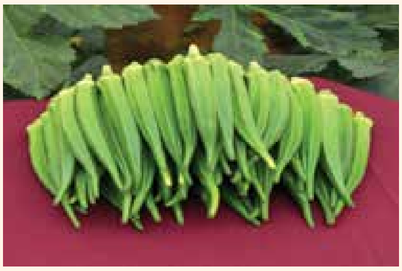

Pomegranate – Solapur Anardana


Guava – Arka Kiran


Bael – Swarna Vasudha


Tomato – Pusa Tomato Hybrid 6


Bottle gourd – Kashi Shubhara


Okra – Arka Nikita


Indian bean – Kashi Bouni Sem- 207


Muskmelon – Thar Mahima


Watermelon – Thar Tripti


Potato – Kufri Chipsona-5


Potato – Kufri Jamunia

GLIMPSES OF THE VARIETIES RELEASED

Nutmeg – Kerala Shree

Small Cardamom – IISR Kaveri

Fennel – RF-290

Mango ginger – IISR Amrit

Cocoa – Vittal Cocoa Hybrid-2

Cashew – Nethra Ganga (H-130)

Coconut – Kalpa Shatabdi

Tuberose – Arka Vaibhav

Crossandra – Arka Shreeya

Gladiolus – Arka Amar

Velvet bean – Arka Daksha

Ashwagandha – Arka Ashwagandha

❑

3.
Crop Management

Research and innovations from various ICAR institutes aimed at enhancing crop yields, managing pests, detecting diseases, and promoting sustainable practices. Key initiatives in field crops emphasized sustainable solutions. For instance, broad bed furrow sowing in soybean increased yields by 20-25% by enhancing moisture retention and soil fertility. In jute farming, deficit irrigation, optimized using AquaCrop modeling, boosted fiber yields by up to 44%, particularly during dry spells. Intercropping systems, such as tobacco with blackgram in Karnataka, have proven effective in improving land efficiency and productivity, while customized fertilizers have enhanced tobacco yields by 15%. Environment-friendly farming practices, like raised bed systems and zero-tillage wheat farming, optimized energy use and irrigation. Water-efficient sugarcane clones have been identified to reduce water consumption while maintaining high yields. Additionally, multi-layer seed coatings, which incorporate fungicides, insecticides, and biofertilizers, improved crop establishment, and the use of nano-zinc oxide increased chickpea and urdbean yields by up to 35%. The Eco-friendly Irrigation Alert System (e-IAS) and methanotroph formulations contributed to water conservation and a reduction in methane emissions in rice fields. In pest management, AI-based pheromone traps have been developed to monitor cotton pink bollworm in real-time, providing data for pest control via mobile apps. Intercropping maize with crops like cowpea has reduced fall armyworm infestations by up to 60%, encouraging natural predators and minimizing pesticide use. Pest-resistant maize and cotton varieties, alongside molecular diagnostic tools for wheat diseases, enhanced pest and disease management strategies. Microbe-based technologies, such as Pseudomonas fluorescens, have proven effective in controlling chickpea wilt, while nano-sulphur and Fluopyrum nematicides have been useful for managing pests in jute and tobacco. The Pusa MeFly Kit offers an eco-friendly solution for managing fruit flies. Integrated pest management strategies and AI-based pest detection systems have shown promise in managing pests in crops like maize and mustard. Research on rice false smut and water contamination has introduced magnesium oxide nanoparticles, which effectively remove pesticides from water, contributing to environmental sustainability. Additionally, biological control agents such as Trichogramma chilonis and Bacillus subtilis have been used to control pests and extend the shelf-life of mango and litchi. In horticulture, several studies focused on improving crop quality and yield. In pomegranate, light thinning and foliar application of 2,4-D optimized fruit weight and yield, while high-density planting and fertigation benefited guava. Techniques like vertical nursery expansion in apple rootstocks and organic matter recycling in Annona hybrid Arka Sahan improved soil nutrients and productivity. Pollination management strategies for date palms and coconut farming systems have further increased crop efficiency. In vegetable crops, drip irrigation and mulching significantly boosted yields in okra and tomato. Nano-urea application improved nitrogen use efficiency in ginger and turmeric, while microbial treatments like Kush Bio-Pulse have controlled grape diseases like downy mildew. The development of a systemic suckericide for tobacco and a PCR-based diagnostic protocol for bacterial blight in pomegranate are additional advancements supporting sustainable agricultural practices. These innovations offer practical, eco-friendly, and cost-effective solutions that benefit both farmers and the environment.

FIELD CROPS

Crop Production

Conservation agriculture practices in soybean: Soybean, a rainfed crop, faces challenges due to climate change, including floods, poor rainfall distribution, dry spells, imbalanced nutrient application, and soil degradation, limiting productivity. Conservation agriculture practices are essential to boost soybean yields and restore soil fertility. The Broad Bed Furrow (BBF) sowing method is a climate-smart technology that maintains optimal moisture and drains excess water. Long-term studies on BBF with residue retention (PBBF + R) have increased soybean yield by 20-25%, improving soil nutrients and organic carbon. Additionally, the soybean-potato-wheat system under

Overview of soybean-potato-late wheat cropping sequence under PBBF + R system

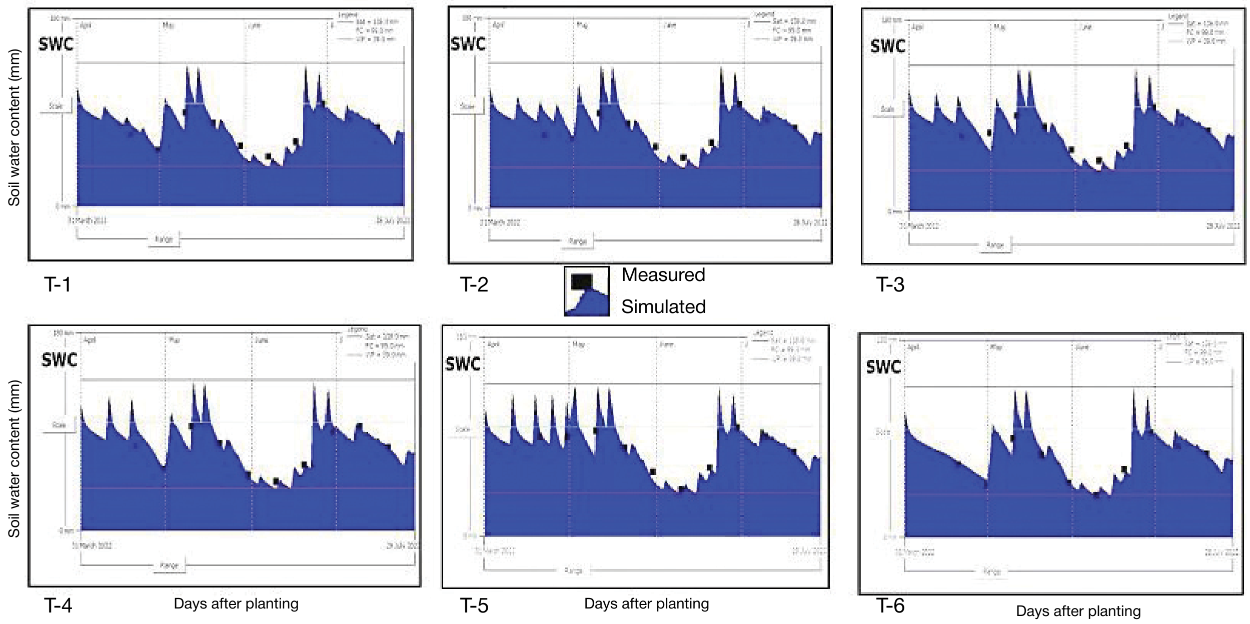
PBBF + R shows higher productivity (soybean seed yield 32.4 q/ha, potato yield 225 q/ha and late-sown wheat yield 72.0 q/ha), and improved soil health.

Optimization of deficit irrigation water usage for maximization of jute fibre yield: India is the top producer and exporter of jute, accounting for nearly 70% of global production. However, jute productivity in India is often affected by dry spells and erratic rainfall. To assess the impact of dry spells and optimize deficit irrigation, an open-field experiment was conducted on jute cultivation under varying soil moisture depletion (DASM) and estimated crop water requirements (ETc). Results showed that irrigating at '50% DASM with 75% ETc' or '75% DASM with 100% ETc' during the pre-monsoon season significantly benefited olitorius jute in alluvial soils of the sub-tropical climate. The best fiber yield and water productivity were achieved with soil-water depletion ranging from 100% to 50%. Irrigation scheduling led to a 23–44% yield increase-compared to rainfed conditions. The AquaCrop model accurately simulated soil moisture, biomass, and canopy cover. The study recommends deficit irrigation as an effective strategy to mitigate dry spells and reduce yield gaps.

Crop intensification in Karnataka light soils: Among the intercropping systems evaluated, the tobacco + blackgram (2:1) combination achieved the highest total system productivity (TEY 1,256 kg/ha), due to minimal adverse effects on tobacco yield, better overall yield, and favourable market prices. Land-use efficiency, measured by LER, increased by 19% in the tobacco + blackgram intercropping system compared to sole tobacco cultivation.

Potassium schoenite as an alternate source of potassium for FCV tobacco: Boronated potassium schoenite (BPS) was identified as an alternative to Sulphate of Potash (SOP) for potassium supply. BPS also provides additional nutrients, including magnesium (Mg), sulfur (S), and boron (B), contributing to balanced fertilization.

Tobacco + blackgram (2:1 ratio)



Simulated and measured soil water content for jute plants (t/ha) from germination to maturity grown in alluvial soils of West Bengal under six irrigation water treatments plotted in the AquaCrop Model

Customized fertilizers for FCV tobacco: Customized fertilizers (recommended NPK doses in a pre-mix) along with secondary and micronutrients, increased cured leaf yield by 15% compared to straight fertilizers. Nutrient uptake (NPK) improved, and tobacco quality parameters, including nicotine, reducing sugars, and chlorides, remained within acceptable limits.

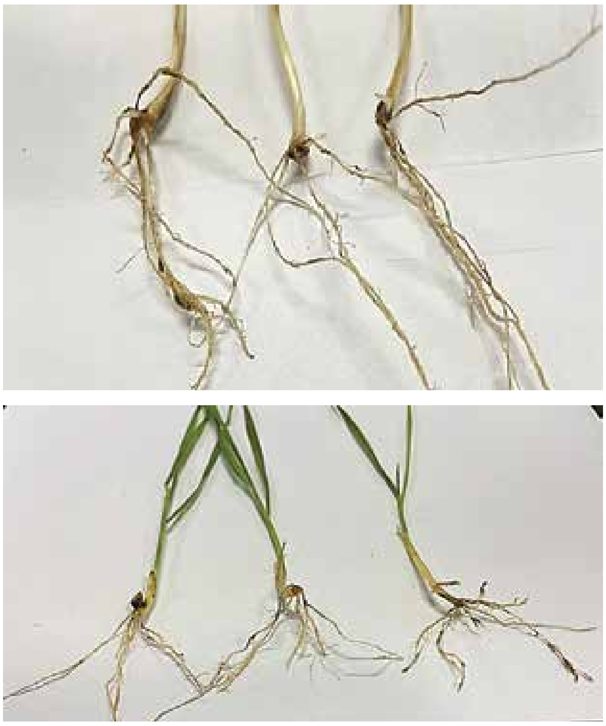
Straight fertilizer

Customized fertilizers

Designing environmentally clean agricultural production model: The raised bed and furrow system showed a 5.5-6% higher system productivity than the flatbed, while cereal-legume integration boosted productivity 2-2.5 times over the conventional maize-wheat system. Both raised bed and furrow, and cereal-legume integration, resulted in higher net returns. Environmentally, the raised bed and furrow system had significantly higher energy-use efficiency (EUE) at 8.29% and energy productivity (EP) at 1.54 kg MJ^{-1} than flatbed. Cereal-legume integration reduced the carbon footprint on energy, productivity, and economics by 2.5-3 times compared to maize-wheat. Additionally, the eco-efficiency index (EEI) for the raised bed and furrow system was 18.9% higher than flatbed. Among cereal-legume integrations, maize+cowpea+soybean-wheat+mustard and maize+cowpea+soybean-wheat+lentil had 90.7% higher EEI compared to the maize-wheat system.

Cereal-legume integration

Early occurrence of crown root initiation (CRI) stage in wheat under zero-tillage condition: Understanding crown root initiation (CRI) stages in wheat is essential for optimizing irrigation timing and improving crop production. This study evaluated CRI in wheat under a long-term conservation agriculture-based rice-wheat system with six tillage and residue practices, including zero-till direct-seeded rice (ZTDSR) and conventional tillage (PTR-CTW). Results showed CRI occurred at 16 days after sowing (DAS) for zero-tillage treatments and 18 DAS for those with residue, while conventional tillage showed CRI at 23-25 DAS. Zero-tillage wheat also had significantly longer crown roots



Crown-root initiation in zero-tillage wheat at 16 DAS

(3.7 cm) compared to conventional tillage (0.4 cm). The study recommends shifting the first irrigation to 16-18 DAS for zero-tillage wheat, instead of the usual 25 DAS.

Water efficient sugarcane clones for sustaining sugarcane production under water-limited conditions: A study to identify water-efficient sugarcane clones for maximizing cane yield under water-limited conditions found that clones such as Co 85019, Co 10026, Co 12009, Co 13014, Co 14002, Co 14025, Co 15015, and Co 15018 exhibited water efficiency (> 5 kg/m^3). Among the germplasm clones, Fiji 55, ISH 111, ISH 107, Pathri, and Gungera demonstrated better water productivity and lower water footprint in terms of sugarcane production per unit of water. Additionally, thermal imaging for estimating canopy temperature was identified as an effective method for screening large breeding populations under water-limited conditions.

Multilayer seed coating technology for seed protection and input delivery for advancing sustainable agriculture: In response to climate change and agricultural stresses, ICAR-IIOR, Hyderabad developed a multilayer seed coating technology that applies multiple layers of crosslinked biopolymers, embedded with crop inputs such as fungicides, insecticides, biofertilizers, and microbial agents. This technology safeguards seeds from both biotic and abiotic stress, while simultaneously delivering essential inputs during seed germination and plant growth. Tested on crops like groundnut, sesame, and linseed, it improves seed germination, seedling vigour, and crop establishment. The controlled release of inputs reduces the need for reapplications, thereby lowering costs and minimizing environmental impact. Field trials on groundnut demonstrated a 20-30% yield increase, driven by enhanced efficiency and reduced pest damage. The technology has now been standardized for commercialization and field application.

Standardization of nano zinc oxide dosages for enhanced pulse crop nutrition: Field experiments at ICAR-IIPR, Kanpur, evaluated the effect of nano zinc oxide as a nano-fertilizer in pulses. The study compared different zinc management practices, including a liquid formulation of nano zinc oxide from ICAR-CIRCOT, Mumbai. In chickpea, a spray of nano zinc oxide at 50 mg/L (pre-flowering and pod formation) resulted in a significant yield increase of 23.7-25%, ranging from 2,247 to 2,309 kg/ha. In urdbean, the 50 mg/L spray also showed a 31-35% higher yield (941-1,043 kg/ha) compared to the control, while a 25 mg/L spray produced similar results. Thus, for chickpea, nano zinc oxide at 50 mg/L is the optimal choice, while for urdbean, a 25 mg/L spray is more effective.

Eco-friendly irrigation alert system: The Eco-friendly Irrigation Alert System (e-IAS) consists of a sensor attached to a perforated pipe installed at the desired depth in rice fields. The sensor connects to a microcontroller and relay module, and the entire system is powered by a 12 V battery, which is charged by a solar

Multi-layer Multi-input double layer Single layer Untreated control

Effect of multi-layer seed coating on the germination and disease incidence under field conditions

Eco-friendly Irrigation Alert System

panel on the structure. This system can save up to 30% of irrigation water without negatively affecting grain yield, increasing water productivity by 40%. It also boosts net returns for farmers by reducing pumping costs and fuel consumption, while lowering methane emissions from rice fields by approximately 37%.

Eco-friendly methanotroph formulation for mitigation of methane emission from rice: The present invention relates to a 'Tamarind-Acacia-based Methanotroph Formulation' designed to reduce methane (CH_4) emissions from rice fields. The novel methanotroph strain, *Methylobacterium* sp. (MT22-NRRI), was isolated from Sundarban mangrove sediment. The formulation is created by combining tamarind seed coat and gum-acacia powders with novel methanotrophs. This formulation not only reduces methanogenesis (methane production in soil) but also enhances methane oxidation in rice fields. It has the potential to reduce methane emissions by up to 15% in lowland rice ecosystems.

Tamarind-Acacia-based Methanotroph Formulation application in rice-based cropping system at ICAR-NRRI, Cuttack

Liquid formulation of endophytic nitrogen fixing bioinoculant for rice (NRRI-EndoN): *Azotobacter chroococcum* Avi2 (NRRI EndoN, MCC 3432 NCBI accession no.: KP099933), a native endophytic nitrogen-fixing bacterium, has been explored as a potential diazotroph for rice. Isolated from the root of Swarna, NRRI-EndoN's endophytic nature was confirmed using Fluorescence Resonance Energy Transfer (FRET)-based techniques. *In-vitro* and *in-vivo* analyses in rice confirmed its diazotrophic efficacy. A liquid formulation of NRRI-EndoN, with a shelf-life of over 12 months, was developed for use as a rice root-dip treatment (recommended dose: 250 mL/acre) before transplantation. Additionally, promising results were observed in wheat, as evaluated by ICAR-NIPB, New Delhi. Based on validation, NRRI-EndoN can increase rice yield by 10.31% while saving about 25% of chemical nitrogen. The product is priced at ₹ 75/250 mL, ₹ 120/500 mL, and ₹ 200/1 L for sale at the Institute's ATIC. This marks the first time a liquid formulation of *A. chroococcum* as an endophyte has been developed and used in the field.

Bridging the yield gap in groundnut through improved agro-technologies: Bridging the yield gap through improved agro-technologies resulted in higher yields and better economic returns for Spanish bunch TG 37A with the improved (ICM) practice. This practice included rhizobium inoculation with IGR 6 or IGR 40 at 1.25 kg/ha for biological nitrogen fixation (BNF), PGPR 'NUTBOOST' at 1.25 kg/ha, FYM at 5 tonnes/ha, recommended NPK (25:50:25 kg/ha), gypsum for alkaline soils (500 kg/ha applied in two equal installments: basal and at earthing up), pre- and post-emergence herbicides, and necessary plant protection measures (including soil application of *Trichoderma viride* at 2.5 kg/ha mixed with 500 kg of FYM/ha). Similar results were observed for Virginia bunch KDG 128 across both spring-summer and *kharif* seasons. The study concludes that adopting the improved practice (ICMP) can ensure higher and more stable yields in groundnut across different seasons and varieties.

Effect of endophytes and mulching on yield parameters under salinity: Pooled data from three years showed that the highest pod yield (1,613 kg/ha) was achieved with the application of Endophyte REN51N (seed treatment + furrow application at 45

DAS) combined with wheat straw mulch at 10 tonnes/ha, which was comparable to REN51N Endophyte applied alone. Endophytes alone increased pod yield by 23.5-36.4% over the control. Additionally, mulch application reduced soil salinity by 1 dS/m compared to the control. The combination of mulching and endophytes resulted in a 54-56% increase in pod yield over the control.

Conservation tillage and residue management practices: Pod yield of groundnut, gross production efficiency yield (GPEY), seed and stalk yields of mustard, and straw yield of chickpea and wheat were higher under conventional tillage with residue incorporation (*kharif*) followed by zero-tillage (*rabi*). Significant differences were observed in mustard seed and stalk yields. Groundnut haulm yield and wheat grain yield were higher under conventional tillage with residue incorporation (*kharif*) followed by conventional tillage (*rabi*), though differences were not significant. Chickpea seed yield was higher under zero-tillage with residue retention (*kharif*) followed by zero-tillage (*rabi*), but differences were non-significant. The groundnut-wheat system had the highest GPEY. Pod and haulm yields of groundnut, mustard seed and stalk yields, and GPEY were highest under T4 (minimum tillage + residue retention + 100% RDF for both crops), although the increase in groundnut pod yield was non-significant. T4 was comparable to T2 and T6 for mustard seed yield and GPEY, and to T6 for mustard stalk yield. T4 also showed similar results to other treatments, except T1 (farmer's practice) and T5 (minimum tillage + residue retention + 100% RDF + DGRC culture) for groundnut haulm yield.

Weed control in groundnut: Two-season study on refining/identifying an efficient weed control strategy confirmed the proven efficacy of "Diclosulam 26 g/ha as PRE fb Fenoxaprop-p-ethyl 78 g/ha as PoE" for season long weed control due to higher yield and economics under Southern Saurashtra Region of Gujarat. Similar was the response during *kharif* 2023 also. This best herbicide treatment combination was followed by the next best treatment, viz. Diclosulam 26 g/ha as PRE fb Clethodim 180 g/ha as PoE (20-25 days after emergence). The dominant weed species found in the Southern Saurashtra Region include 1) sedges, like *Cyperus* spp.; 2) grasses, like *Dactyloctenium aegyptium, Echinochloa colonum* and *Diachanthium annulatum*.; and 3) broad leaved weeds, like *Digera arvensis, Vernonia cinerea, Phyllanthus* spp., *Vigna* spp., *Eclipta alba, Alternanthera* spp., *Ammania bacifera, Euphorbia hirta, Tridax procumbens* and *Commelina benghalensis.*

Estimation of biotic stress-induced yield losses in crop plants: Ground data on damages caused by rice yellow stem borer and mustard powdery mildew at different severities and their yield were recorded during winter 2023 and summer 2024 to estimate real time crop yield losses. In addition, imageries of symptoms at various severities, GPS and meteorological data were collected. Yield loss due to yellow stem borer in directly sown rice was manually estimated as 19.58%, 44.31%, 48.03% and 58.42% when there were white ear damages of 1-25%, 26-50%, 56-75% and 76-100%, respectively. Similarly, the reduction in mustard seed yield due to powdery mildew was 32.2%, 51.39% and 70.78% at various severities of 25% to 50%, 51% to 70% and 71% to 90%, respectively. Powdery mildew infection in mustard reduced the 1,000 seed weight which ranged from 16.49% to 24.74% in addition to the decline in oil content from 4.40% to 10.23%. Further processing of ground data digitally, using AI is in progress.

Crop Protection

AI pheromone trap for real-time monitoring of cotton pink bollworm in Punjab: ICAR-CICR, Nagpur, has developed an AI-based smart pheromone trap to overcome the limitations of traditional traps. The system records trapped pink bollworm moths at hourly intervals and sends images with corresponding weather data to a remote server. The AI algorithm (YOLO) processes the images, counts the insects, and delivers the information to users via mobile/PC apps. The traps were deployed at 18 locations across three cotton-growing districts in Punjab (Bathinda, Mansa, and Muktsar) to provide daily and weekly pest alerts and management advisories based on economic threshold levels (ETLs). Pink bollworm management strategies, tailored to crop windows, are shared with cotton growers as 30-second voice messages via mobile networks.

Intercropping for the sustainable management of fall armyworm in maize: Maize (*Zea mays*), is highly adaptable but susceptible to pests like the fall armyworm (FAW), *Spodoptera frugiperda*. Field experiments in three Indian locations (Hyderabad, Telangana, Dholi, Bihar; Kolhapur, Maharashtra) demonstrated that intercropping maize with crops such as cowpea, groundnut, and greengram significantly reduced FAW infestations. In Hyderabad, intercropping with cowpea and groundnut reduced FAW damage by 60.16% and

Cowpea as intercrop in maize cropping system

Groundnut as intercrop in maize cropping system

53.82%, respectively, compared to sole maize. In Dholi, FAW damage was reduced by 34.77% with cowpea, 26.62% with greengram, and 23.31% with blackgram. In Kolhapur, maize intercropped with cowpea and groundnut reduced FAW damage by 27.97% and 25.17%. These intercrops also enhanced populations of natural enemies (e.g coccinellids, spiders, earwigs), suppressed weeds, and improved yields. Thus, intercropping, a key component of Integrated Pest Management, can reduce reliance on synthetic insecticides, improve ecological balance, and increase economic returns for smallholder farmers.

Diagnostic assay for pre-harvest detection of *Tilletia indica* infection in wheat plants: A new diagnostic technology for the rapid and accurate detection of *Tilletia indica* caused by Karnal bunt (KB) disease in wheat has been developed by ICAR-IIWBR, Karnal. The developed assay uses quantitative real-time polymerase chain reaction (qPCR) and a primer set derived from glyceraldehyde 3-phosphate dehydrogenase (GAPDH) gene of *T. indica* to identify the presence of the pathogen. The qPCR assay demonstrates high sensitivity, detecting the KB pathogen even in asymptomatic wheat plants at various growth stages. Validated across 10 wheat cultivars, the assay proved reliable and versatile. This diagnostic tool enables rapid, specific, and sensitive detection of KB, supports screening for resistant wheat genotypes, and aids in developing strategies to mitigate Karnal bunt's impact on wheat production. By facilitating pre-emptive actions, it enhances disease management and safeguards wheat crops against KB.

Diagnostic assay for rapid field diagnosis of flag smut disease in wheat: Flag smut, caused by *Urocystis agropyri*, can significantly reduce wheat yield and quality. Addressing this, the ICAR-IIWBR, Karnal, has developed the world's first molecular assay for the rapid detection of *U. agropyri*. The assay utilizes species-specific primers designed by analyzing partial sequences of the ITS DNA region of *U. agropyri* against related and unrelated phytopathogenic fungi. PCR tests confirmed the presence of *U. agropyri* in all samples from infected fields and plant tissues at various growth stages, while no detection occurred in samples from healthy plots, demonstrating 100% reliability. This assay enables efficient, high-throughput detection of *U. agropyri* in wheat and soil samples with minimal labour, making it a valuable tool for quarantine surveillance and managing flag smut.

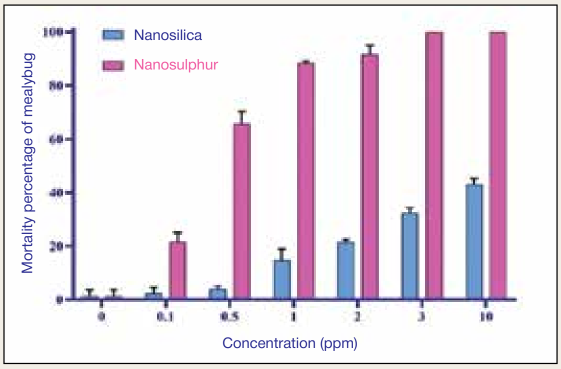
First report of Leaf Spot on maize caused by *Curvularia verruculosa* in India: Curvularia leaf spot affects maize (*Zea mays*) worldwide and is commonly caused by *Curvularia lunata*, C. *geniculata*, and C. *pallescens*. Upon morphological and microscopic observation, the pathogen associated with the disease symptoms was *C. verruculosa* which was further verified with the molecular markers and gene sequence of internal transcribed spacer 1 (ITS 1) and ITS 4 rDNA region and the *glyceraldehyde-3-phosphate de-hydrogenase (gpd)* gene. The similarity percentage of E40 isolate matched 100% with MH859788 (CBS444.70) of the *C. verruculosa* strain for ITS and 100% with LT715824 (CBS150.63) of the *C. verruculosa* strain for *gpd* after NCBI BLASTn searches. As a result, *C. verruculosa* was determined to be the pathogen by both morphology and molecular characteristics. The pathogenicity test and Koch's postulate evidence corroborated the previous findings. Finally, it was concluded that this is the first report of leaf spot caused by *C. verruculosa* on maize in India.

Integration of microbe-based technologies for the management of chickpea wilt: Bio-efficacy trials were conducted at KVKs and AICRP to evaluate ICAR-NBAIM's microbe-based technologies for disease control in chickpea, aiming to reduce fungicide use and promote organic farming. The tested products included Kush Eco-Pesticide (*Pseudomonas fluorescens* PF-08), Kush Bio-Pulse (*Trichoderma asperellum* UBSTH-501 and *Bacillus amyloliquefaciens* B-16), Kush Bio-Care 24 (*Bacillus subtilis* RP-24), Kush Crop Care (*B. amyloliquefaciens* B-16), and Kush Green Fungicide (*T. asperellum* UBSTH-501).Pooled results showed the lowest wilt incidence with Kush Bio-Pulse (10.25%), followed by Kush Bio-Care 24 (15.36%), Kush Green Fungicide (16.05%), Kush Crop Care (18.96%), and Kush Eco-Pesticide (21.25%), compared to untreated plants (39.36%–46.95%). Yield improvements were significant across all treatments, with Kush Bio-Pulse achieving the highest yield (1,580 kg/ha), followed by Kush Bio-Care 24 (1,325 kg/ha). Untreated controls yielded the lowest

Use of nanoparticles for managing pests and diseases in jute and carbon nanotubes for salinity tolerance

***Effect of nanoparticles on jute mealybug*:** Over the past decade, the mealybug (*Phenacoccus solenopsis*) has emerged as a significant pest of jute and mesta. A study evaluated the efficacy of nano-silica (30 nm) and nano-sulphur (25 nm) against 2nd instar mealybug nymphs using concentrations ranging from 0.1 ppm to 10 ppm. Nano-silica (30 nm) showed limited effectiveness, with a maximum mortality of 32.38% at 3.0 ppm. In contrast, nano-sulphur (25 nm) proved highly effective, achieving 88.37% mortality at 1.0 ppm and 100% mortality at 3.0 ppm under laboratory conditions. Nano-sulphur demonstrates strong potential for managing mealybug infestations in jute.

***Effect of nano-sulphur on yellow mite in jute under field conditions*:** The efficacy of nano-sulphur (25 nm) against yellow mite (*Polyphagotarsonemus latus*) was evaluated under field conditions. Mite-infested plants were tagged, and mite populations were counted using a magnifying glass. Nano-sulphur was applied at concentrations ranging from 0.00001 ppm to 0.1 ppm, and live mite populations were reassessed after 48 h. Nano-sulphur proved highly effective, with an application of 0.01 ppm reducing the mite population from 81.67 (pre-treatment) to 9.67 per cm² of leaf area. This indicates its strong potential for managing yellow mites in jute under field conditions.



Effect of nano-particles on jute mealybug (*Phenacoccus solenopsis*)

(695.25 kg/ha). Treated plants produced 1.5 to 2.25 times more yield than untreated ones, demonstrating effective disease control and enhanced productivity.

High throughput *in-vitro* screening technique for jute stem rot: Screening for resistance to stem rot is typically conducted under sick plot conditions, but this method is resource-intensive and influenced by environmental factors. To address these challenges, a high-throughput screening technique has been developed. At 60–70 DAS (plant height >1.5 m), three 7-cm stem segments are taken from the mid-length of a plant. These segments are inoculated by puncturing the bark with a needle and placing a PDA plug with the growing mycelial edge of *Macrophomina phaseolina*. The inoculated stems are kept in a moist chamber at 28–30°C for 48 h, after which lesion lengths are measured. The lesion lengths observed *in vitro* correlate strongly with those under field conditions. Decapitated plants branch at the cut end and produce flowers and seeds. This method is particularly effective for screening segregating material in the development of mapping populations.

Variation in lesion length upon artificial inoculation with *Macrophomina phaseolina*

New molecule for nematode control: Fluopyrum 400 SC at 0.05% concentration resulted in a 60.0% reduction in root-knot index (RKI) and a 41.9% decrease in soil nematode population in tobacco nursery. Under field conditions, it caused a 55.8% reduction in RKI incidence and a 49.1% decrease in soil nematode population. Additionally, the cured leaf yield of FCV tobacco increased by 23%.

Pusa MeFly Kit - A fruit fly management kit for fruit crops: Fruit flies are a major pest of fruit crops resulting in significant crop losses in India. Being also an international quarantine pest, their infestation and insecticidal usage impacts the export potential of fruit crops. The Pusa MeFly Kit is an eco-friendly, cost-effective solution for controlling fruit flies of the *Bactrocera* species, significant pests affecting fruit crops like mango, guava, papaya, citrus etc in India.

Pusa MeFly Kit

Volatile organic compounds-based repellents and oviposition deterrents against cotton whitefly: The cotton whitefly, *Bemisia tabaci* causes severe economic damage as a pest and also as a vector for over

200 viral diseases. Some of the plant virus diseases such as Cotton leaf curl virus (CLCuV) vectored by the whitefly *B. tabaci* impact the cotton production and productivity at times of epidemic infestations in Asian and African countries. This technology is based on plant volatiles associated with the repellence and oviposition deterrence of whitefly, *B. tabaci*. The volatile plant chemicals can be used in sprayable or other suitable formulations such as lures, gels etc., as repellent/ ovipositional deterrent against whitefly *B. tabaci*.

Cotton white fly. Eggs on leaf (*top*); Adult whitefly (*middle*); and Cotton plants (*bottom*)

Diagnostic CAPS markers for detection of phosphine resistance in red flour beetle: Red rust flour beetle, *Tribolium castaneum* is a serious pest of stored grains causing severe economic losses. Phosphine is the most widely used fumigant for control of stored grain pest. However, its continuous use has intensified the resistance in insects affecting the quality of stored grains. The Cleaved Amplified Polymorphic Sequence (CAPS) markers have been developed for quick detection of phosphine resistance for strengthening the current fumigation protocol for red flour beetle.

Indian *Bacillus thuringiensis* strain VKK5 having insecticidal, antimicrobial and plant growth promoting activity: *Bacillus thuringiensis* is known as the most successful microbial insecticide worldwide used against lepidopteran insect pests in agriculture. Native Bacillus isolate VKK5 showing insecticidal activity against *Spodoptera frugiperda* has been found to establish and colonize as endophyte in maize cultivars. This native Bt strain as endophyte in maize plants, complemented with insecticidal activity, lead to an innovative approach for the management of *S. frugiperda*.

Yield loss, economics and management of *Lipaphis erysimi* in Indian mustard: The mustard aphid, *Lipaphis erysimi* is a major pest of *Brassica* and causes yield losses up to 90% in Indian mustard, *Brassica juncea*. The insecticidal control of aphid populations prevents 10.2 to 61.1% yield loss in Indian mustard. Alternate use of *Beauveria bassiana* @ 2 g/l, dimethoate 30 EC @ 1 ml/l, imidacloprid 17.8 SL @ 0.25 ml/l, or thiomethoxam 25 WG @ 0.2 g/l water depending on the extent of aphid population, effectively manages aphids in Indian mustard. This technology strengthened the decision support for effective management of aphids, reduce insecticide cost and increase economic return for sustainable mustard production.

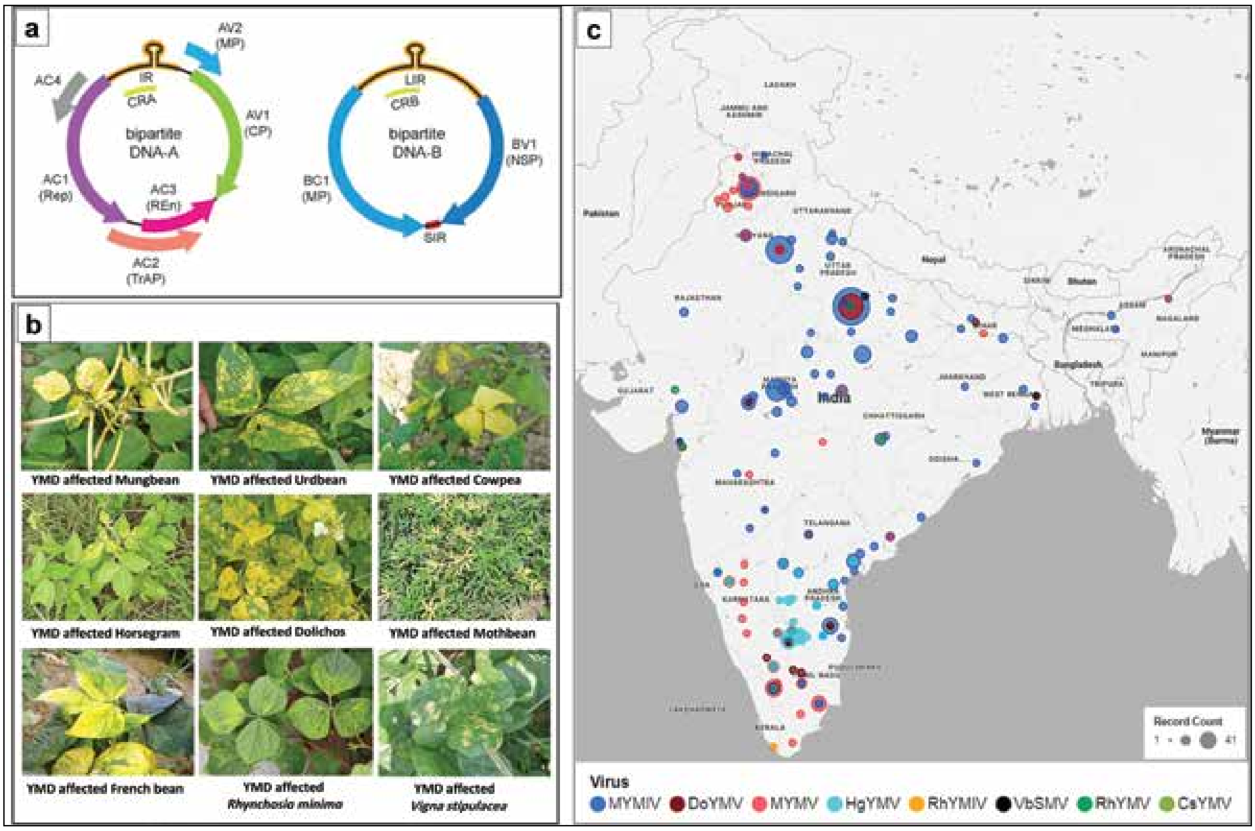
Country-wide distribution map of YMD-causing viruses in pulse crops: A country-wide distribution map was created to examine the prevalence and diversity of begomoviruses causing yellow mosaic disease (YMD) in legumes across India. The map helps identify the presence of YMD-causing viruses in specific locations. Twelve legumoviruses, each with two circular single-stranded DNA molecules (DNA-A and DNA-B), were found to be associated with YMD. These viruses are essential for replication, coat protein formation, and successful infection. Due to similar yellowing symptoms, identifying the specific virus in mungbean, urdbean, cowpea, and soybean is challenging, making accurate diagnosis crucial.

Over 250 symptomatic leaf samples were collected from mungbean, urdbean, cowpea, horsegram, mothbean, and *Vigna stipulacea* across 38 locations in five agro-climatic zones: Central Zone (CZ), South Zone (SZ), North East Plain Zone (NEPZ), North West Plain Zone (NWPZ), and North Hill Zone (NHZ). The study generated 119 full-length and 72 partial DNA-A

Lipaphis erysimi on Indian mustard

sequences, along with 106 full-length DNA-B sequences, from MYMIV, MYMV, HgYMV, DoYMV, and RhYMV. Additionally, data from public databases were compiled, covering 171 locations across 16 countries, resulting in 581 DNA-A and 287 DNA-B sequences from 119 locations for eight legumoviruses in India. The distribution analysis identified three legumoviruses—CsYMV, RhYMIV, and VbSMV—reported from single locations in Raipur (CZ), Thiruvananthapuram (SZ), and Lucknow (NEPZ), affecting *Cajanus scarabaeoides, Rhynchosia minima,* and *Mucuna pruriens* (velvet bean), respectively. RhYMV was found in four locations across CZ and NEPZ, while HgYMV was confined to SZ, with 60 reports from 30 locations. DoYMV and MYMV were observed in all zones except NHZ, with 43 and 146 reports, respectively. MYMIV had the broadest distribution, present in all five agro-climatic zones with 324 reports. The findings highlight regional prevalence: MYMIV, MYMV, and HgYMV dominate the SZ, often in mixed infections. The 581 reports from 119 locations covered 53 hosts, including 22 legume and non-legume crops and 31 weed species. MYMIV is the most abundant (55.9%) and dominant (0.56), followed by MYMV and HgYMV. Regionally, HgYMV and MYMV are prevalent in SZ, MYMIV dominates CZ, and both MYMIV and MYMV are significant in NEPZ. The NEPZ shows the highest diversity, while SZ exhibits high species evenness, emphasizing the need for zone-specific management strategies.

Quality attributes of the pupal parasitoid, *Tetrastchus howardi* on plassey borer pupa: Plassey borer, *Chilo tumidicostalis* pupae was found to be a



T. howardi emerging from Plassey borer pupa

Adult *T. howardi*

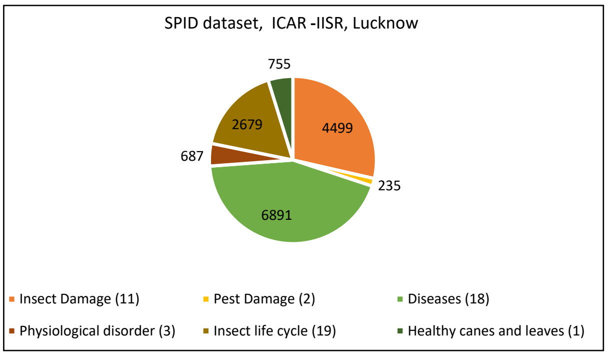
Plassey borer pupae

suitable host for multiplication of pupal parasitoid, *Tetrastichus howardi*. The mean number of progeny was observed as 99.95/pupa. The smaller host pupa gave rise to a small number of parasitoids (97 adults/pupa), whereas larger ones are supported by more parasitoids (116/pupa). A female biased sex ratio (>93%) was observed on plassey borer pupae. The nutritional quality and size of the host should be considered when selecting alternative hosts for mass-rearing of parasitoids.

Mapping of ratoon stunting disease and its impact on quantitative and qualitative parameter of sugarcane: A total of 228 DUS sugarcane germplasms were screened for the RSD pathogen in 2023-24. Among them, 82 germplasms showed less than 10%, 58 germplasms exhibited 10–20%, 31 germplasms displayed 20–30%, 24 germplasms illustrated 30–40%, and 19 germplasms showed more than 40% cane node infection. The identified susceptible varieties were CoS767, CoP 9206, CoP 9702, CoS 8432, CoS 8207, CoSe 03279, CoS 94270, UP 05, CoLk 9414, and CoH 94, while the resistant varieties (Ikshu ISH 12, SC 8001-6, LG 05201, Ikshu ISH 22, Ikshu ISH 9, Ikshu ISH 1, CoS 88230, Ikshu ISH 3, SC 91-2, SC 91-7, LG 02005, ISH 135, ISH 126, and CoS 99259) were planted again to validate the disease reactions and impact on qualitative parameters. The disease intensity had an impact on all qualitative parameters. Additionally, all resistant varieties, except for Ikshu ISH 12, showed slightly more susceptibility (1-2 % increase).

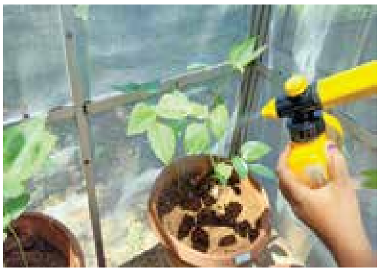
Ratoon stunting disease in sugarcane

Artificial intelligence-based detection of insects, pests and diseases: A total of 1,307 RGB images of Red Rot, Wilt, Smut, Pokkah Boeng, YLD, Top Rot, Leaf Scald, Leaf Scorching, Ratoon Stunting Disease, Scale Insect, Mealy bug, White fly, Aphid, Black bug, Top Borer, Internode borer, Termite and Porcupine damage symptoms were captured manually through different cameras ([Canon EOS 77D DSLR camera), smartphone One Plus 7T Pro HD1911 (OnePlus Technology (Shenzhen) Co., Ltd.), Android Version 11 (Oxygen OS 11.0.7.1 HD01AA), SnapdragonTM 855 plus processor camera and 16.1 MP Sony Cyber-Shot DSC-H70 with 10x Wide-Angle Optical Zoom G Lens camera]. The images were collected from susceptible varieties such as Co 0238, CoJ85, CoJ64, CoSe 18452, CoLk 94184, CoLk 14201, CoS 8436, Co 1148, CoLk 11203 and CoS767 etc. In total, the image repositories of 15, 746 RGB images of insects, healthy and injured symptoms of insects, pests, diseases are available at SPID dataset.



Evaluation of synthetic form of plant volatiles for management of key pests of crops: Volatile profiles induced by whitefly in cowpea, greengram, blackgram and soybean were studied. Fourteen volatiles which occurred majorly in all the profiles were selected to identify useful volatiles which repel or disturb the life cycle of whitefly. In no-choice tests, treatment of soybean plants with 500 ppm of Eicosane and Squalane reduced the settlement of whitefly adults for feeding by 60% and 55%, respectively 48 h after treatment while, there was no reduction in settlement in ethyl acetate and control. In choice test, Squalane and Eicosane treatment

Synthetic form of plant volatiles 500 ppm



Foliar application

Whitefly

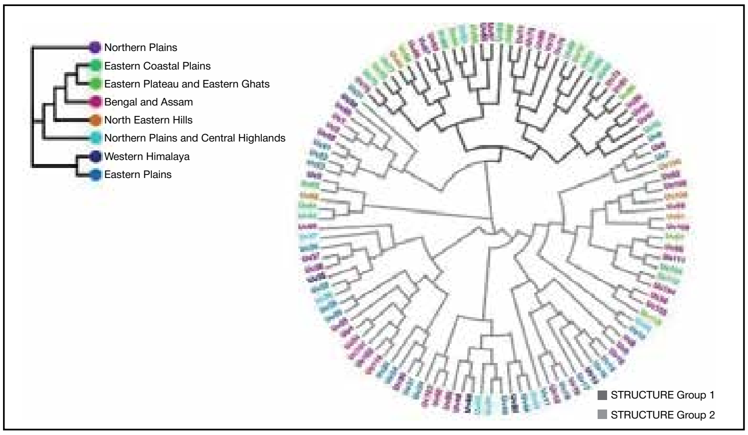
Evaluation of repellent activity of plant volatile

in soybean seedlings at 500 ppm repelled whitefly from settlement and feeding by 74.34% to 83.4% at 24 h and 40.43% to 46.81% at 48 h after treatment, respectively. Feeding of fall armyworm on semi-synthetic diet treated with Cyclohexane and Eicosane at 500 ppm reduced its relative growth rate (RGR) from 27.51% to 34.58%, relative consumption rate (RCR) from 52.30% to 54.54% and approximate digestibility (AD) from 49.02% to 52.62%.

Molecular diversity of *Ustilaginoidea virens* in agro-ecological zone of north, east and north-eastern India: Moderate level of genetic diversity was observed among 112 *U. virens* isolates collected from eight agro-ecological region covering states of North, East and North-eastern of India. Allele frequency was in the range of 0.598 to 0.748. Genetic diversity was highest (0.493) among the isolates belong to eastern coastal plains while it was lowest (0.311) in North-eastern hills. The dendogram analysis have shown three main clusters. Cluster I comprised almost all isolates from one region, i.e. Northern plains (NP) includes isolates mostly from UP while Cluster II formed the highest group and isolates are included from five agro-eco regions, viz. Eastern coastal plains (ECP), Eastern plateau and eastern ghats (EP and EG), Bengal and Assam zone (BAZ), North eastern hills (NEH), Northern plains and central highlands (NP and CH). These groups accumulated isolates from almost all the eastern (WB, Odisha, few eastern UP), north-eastern (Assam, Meghalaya) and central (MP) states. The Cluster III mainly grouped isolates from two agro-eco regions, i.e. Western Himalayan region (WHR) (isolates of Himachal Pradesh, Uttarakhand) and Eastern plain region (EPR) (isolates from parts of UP). Structure analysis grouped mainly two clusters. Analysis of molecular variation showed more genetic variation within populations (92%) and less among populations (8%). Highest genetic differentiation (0.24) was found between population of Eastern plateau eastern ghats and Eastern plains, whereas lowest differentiation (0.03) was observed among the population of Eastern Plain and Northern Plains and Central highlands. But no differentiation was observed between populations of BAZ and NEH; populations of Northern plains and Western Himalaya and Eastern plains. The study will help in agro-eco region based management strategy of false smut disease of rice.

Classification of rice false smut severity using hyperspectral spectrometry: Rice false smut (RFS) caused by *Ustilaginoidea virens* has emerged as a serious grain disease in rice production in India. The disease is characterized by the transformation of individual rice florets into false smut balls. In current research work, the purpose was to characterize the RFS's spectral reflectance to identify its sensitive spectral region. The

Rice plants with 75-100% white ear symptom



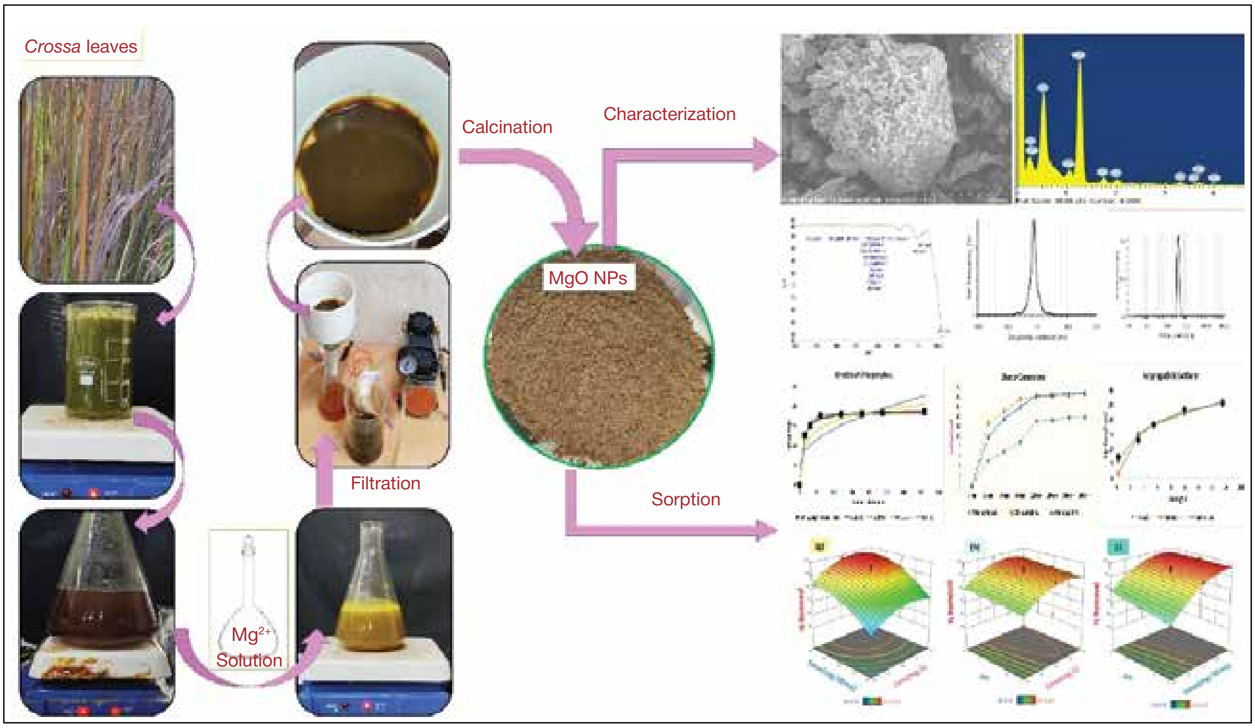
Neighbor-joining tree constructed based on Rogers 1972 distance measures

damage was classified based on the Disease Severity (DS) percent of RFS samples and the damage scale of RFS (Scale 7 and 9). Result showed that the healthy sample has higher reflectance value than the RFS samples in all the spectral regions. Change in the reflectance for the infected RFS sample as compared to the healthy plant was more pronounced in the 500-552, 677-774, and 800-834 nm (common spectral region identified after performing spectral derivative analysis (SDA)) having correlation coefficient 'r' above 0.6. The analysis of the reflectance change as a function of wavelength (1st derivative) showed that the Visible (VIS) and Near Infrared region (NIR) have high correlation with the DS. The Sensitivity Analysis (SA) was also done to identify the sensitive spectral regions (506-580 and 646-693 nm) based on band depth (BD). Identifying the spectral sensitive regions using SA, the Continuum Removal Analysis (CRA) was done to identify the absorption dips (512 and 684 nm). Finally, seven bands (512, 522, 545, 684, 730, 756 and 812 nm) were identified as sensitive bands for RFS infection. But, as the bands were in close proximity to each other and to reduce data redundancy, the RELIEFF algorithm was used to solve the issue based on accuracy model. The combination of identified sensitive bands from all the methods (SDA, CR and SA) were done and it was found that the combination of bands 522, 684 and 730 nm gave us maximum accuracy of 78.3%.

Facile synthesis of novel magnesium oxide nanoparticles for pesticide sorption from water: The quantum of pesticides in surface as well as drinking water has become a serious health hazard. In this experiment, magnesium oxide nanoparticles (MgO NPs) were synthesized using leaves of purple coloured rice variety (Crossa) and utilized for simultaneous removal of three pesticides namely, thiamethoxam, chlorpyriphos and fenpropathrin from water. The biogenic MgO NPs were characterized using SEM-EDX, FTIR, XRD, DLS, etc. The optimum synthesis parameters (1M NaOH, 80^{O}C and 2 h) resulted in maximum yield of MgO NPs (87.7 mg), minimum hydrodynamic diameter (35.12 nm), poly dispersity index (0.14) and mean zeta potential (-11 mV). Sorption data of the three pesticides fitted well with non-linear Langmuir and Freundlich isotherm models and non-linear pseudo second order kinetic model. The maximum adsorption capacity of MgO NPs for the three pesticides was 87.66 µg/mg, as obtained from the Langmuir isotherm model. Under optimum conditions (initial concentration: 40 mg/L, dose: 30 mg/30 mL and pH: 9), 60.13, 80.53 and 92.49% removal of thiamethoxam, chlorpyriphos and fenpropathrin was achieved with a 100 % desirability, respectively. Thus, the biogenic MgO NPs could be an efficient adsorbent of pesticides and could be recommended for pesticide decontamination in water treatment plants and domestic water purifier systems.

Sub-lethal imidacloprid exposure and its consequences on functional response of *Trichogramma chilonis*: The success of a biological control agent relies on the suppression potential of the intractable pests along with its compatibility with pesticides. Therefore, we reported multigenerational effect of commonly used insecticide, imidacloprid on the functional response of a widely acclaimed egg parasitoid, *Trichogramma chilonis* to different densities of host, *Corcyra cephalonica* eggs. The study investigated the outcomes of the lethal concentrations (LC_5, LC_{30} and LC_{50}) along with control for five continuous generations (F_1 to F_5). The outcomes revealed a type II functional response for the F_5 generation of LC_{30}, both the generations (F_1 and F_5) of LC_{50} and control. A type I functional response was exhibited for F_1 generation of LC_{30} and both the generations of LC_5. A shift in the type of functional response did not alter (decrease) the attack rate over the host eggs treated with LC_5 and LC_{30} in comparison to the control. A significant increase in the searching efficiency (*a*) was observed in the later generation (F_5) under the exposure of LC_5 and LC_{30} imidacloprid concentrations. A lower handling time (Th) in both the generations of the LC_5 followed by LC_{30} treated individuals was observed juxtaposing the control and LC_{50} treatments. The per capita parasitization efficiency (1/Th) along with rate of parasitization per handling time (a/Th) were also considerably high in both the generations of LC_5 and LC_{30} than in the control and LC_{50}, thereby implying positive effects of imidacloprid on the parasitization potential of *T. chilonis*. Altogether, these multigenerational outcomes on the functional response of *T. chilonis* could be leveraged not only in the mass rearing of the parasitoid but also to annihilate the intractable lepidopteran pests under the mild exposure of imidacloprid in IPM programmes.

Dual role of potassium silicate (PS) and salicylic acid (SA) as plant growth promotor and immunity booster against Bakanae disease: This study examined the individual and combined effects of PS (1.0%) and SA (100 mg/L) seed priming on plant growth and



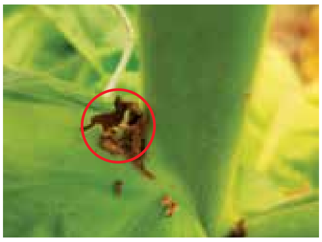
Synthesis of novel magnesium oxide nanoparticles and their utilization for pesticide sorption from water

defense responses against *Fusarium fujikuroi*, the causative agent of bakanae disease. The combined seed priming with SA and PS effectively reduced disease incidence and improved growth parameters, including germination, root and shoot length, plant biomass, and seedling vigour. Treated plants showed significantly higher accumulation of defense enzymes such as phenylalanine ammonialyase (PAL), polyphenol oxidase (PPO), peroxidase (POD), and phenol derivatives. The highest enzyme activity was observed in plants treated with PS+SA at 21 DAS. The treatment of SA (100 mg/L) + PS (1%) had the best effect without causing phytotoxicity. This study suggests that seed priming with SA and PS promotes plant growth and suppresses bakanae disease in rice by activating key defense enzymes and enhancing antioxidant defenses, offering an environment friendly alternative to fungicides for disease management.

Identification of a novel chitinase gene: A novel chitinase gene, *OsChib1* was identified on Chromosome 10, belonging to GH18 (class IIIb) chitinases form a accession of the rice line, Tetep through a comprehensive transcriptomic approach and targeted gene expression analysis. Over-expression of *Oschib1* gene confers resistance against sheath blight disease of rice caused by *Rhizoctonia solani* AG1-IA. This is the first attempt of functional validation of class IIIb chitinase 1 (*Oschib1*).

Assessment of carry over population of Bruchids from fields and early detection of eggs: Choice and No choice test were conducted to evaluate the host preference of bruchid in field condition. Tamarind was preferred host by bruchid. *Samania saman* was the new host recorded for the first time as host of bruchid beetle. Most of the chemical stains were not found suitable for early detection of bruchid infestation as they were not able to stain eggs due to presence of soil on groundnut pods. However, DGR Stain 1 solution stained the groundnut pods and eggs were clearly visible. Hence DGR Stain 1 may be used for early detection of eggs in field itself.

Development of systemic suckericide: A new locally systemic suckericide (SUCKERSTOP™) was synthesized in collaboration with M/s M R Biochem Pvt Ltd, Hyderabad under Public Private Partnership mode and its efficacy was evaluated and found it works effectively (around 95% in controlling the growth of suckers) at the Research Stations of ICAR-CTRI located in FCV tobacco growing regions of Andhra Pradesh and Karnataka and farmers' fields under the Northern Light Soil regions and also in Vinukonda burley tobacco. The ad-hoc recommendation of application of SUCKERSTOP™ 2.5% @ 20 to 25 ml per litre before bud initiation/emergence was also given to the farming community.



SUCKERSTOP™ application

Without suckericide

Identification of resistant sources against insect pests

Fall armyworm, Spodoptera frugiperda : A set of 524 lines was evaluated for foliar resistance to fall armyworm at the V5 phenological stage under artificial infestation. The resistant, moderately resistant, and susceptible lines were defined by leaf damage rating (1-9 Scale) 1.0-4.0, >4.1-6.0, and >6.1-9.0, respectively. Five lines, i.e. IMR 49 (4.69), IMR 610 (4.15), MIL-2-280-1 (2.4), DHO-82-7 (2.6), and DHO-82-2 (3.1) were found promising against fall armyworm.

Pink stem borer, Sesamia inferens : Two hundred two inbred lines along with resistant (DMRE 63, CM 500) and susceptible checks (CM 202) were screened under artificial infestation against pink stem borer. The resistant, moderately resistant, and susceptible lines were grouped based on leaf injury rating of 1-3, >3.1-6 and >6.1-9, respectively. Genotype 343-X/14 (2.93) was found resistant against pink stem borer under artificial infestation.

Development of barley leaf rust differential sets: A differential system for designating *Puccinia hordei* pathotypes, responsible for barley leaf rust in India, has been developed. Screening of 328 isolates, collected since 1999 from India, Bhutan, and Nepal, was conducted using near-isogenic lines (NILs) with known *Rph* genes, barley accessions, and promising Indian barley cultivars. Employing a binomial nomenclature system, 11 distinct *P. hordei* pathotypes were identified and categorized into three molecular groups (A, B, and C). This system, combining virulence phenotypes and molecular genotypes, enhances precision in screening barley germplasm and identifying rust-resistant lines. The establishment of an Indian differential system aids in tracking shifts in virulence patterns, dominance, and the emergence of new pathotypes, supporting effective barley rust management in the future.

List of three sets of differentials for the identification of pathotypes of *Puccinia hordei*

Set 0	Set A	Set B
Astrix	Sudan(*Rph1*)	Egypt-4 (*Rph8*)
Topper	*Rph10*	Emir (*Rph20*)
Q21861(*RphQ*)	*Rph11*	Prior (*Rph19*)
HBL113	*Rph13*	Yeron (*Rph23*)
BHS46	*Rph14*	Abyssinian (*Rph9*)
RD3016	Ribari (*Rph3*)	Gold (*Rph4*)
BH1035	Peruvian (*Rph2*)	Quinn (*Rph2+5*)
PL908	Magnif 104 (*Rph5*)	Bolivia (*Rph2+6*)
RD3013	Cebada Capa (*Rph7*)	Ricardo (*Rph2+21*)
Barley Local	Triumph (*Rph12*)	

Identification of sources of resistance to leaf webber/capsule borer: Among the 29 species of insect pests attacking sesame (*Sesamum indicum*), the leaf webber and capsule borer, *Antigastra catalaunalis*, are the major pests, Hyderabad causing yield losses up to 90%. A total of 276 ICAR-IIOR germplasm, 132 exotic germplasm, and 60 advanced breeding lines were screened for resistance to *A. catalaunalis* over two seasons (2021-22 and 2022-23). Ten genotypes (SES-K-20-1050, SES-3-19-3014, SES-K-20-1062, SES-K-20-2027, IC-205775, IC-500343, SL-11, PI 170757, PI 223014, and PI 285170) showed low pest incidence. These genotypes, along with Swetha (resistant check), Prachi (susceptible check), and PI 170726 (highly susceptible), were selected for further screening under controlled conditions to study the resistance mechanism.

Under controlled conditions, IC-500343 showed the least damage across all categories, with leaf, flower, and capsule damage recorded at 7.32%, 1.39%, and 1.48%, respectively. It also had the lowest capsule content consumed by *A. catalaunalis* (1.50%). Thus, IC-500343 was classified as highly resistant. IC-500343 was less preferred by larvae (3.33) compared to other genotypes, including Swetha, SES-K-20-1062, and SES-K-20-1050, 24 h after release. It was also less preferred for egg-laying. Furthermore, IC-500343 exhibited the highest leaf and midrib trichome density, a longer larval period (13.00 days), and lower adult emergence (69.45%).

Biochemical analysis showed that resistant genotypes had higher levels of biochemical components compared to susceptible ones, both before and after *A. catalaunalis* infestation. After infestation, levels of peroxidase, catalase, ascorbate peroxidase, glutathione reductase, superoxide dismutase, phenylalanine ammonia lyase, polyphenol oxidase, malondialdehyde, total glutathione, and ascorbic acid significantly increased, while lipoxygenase levels decreased. Based on these findings, genotypes IC-500343, SES-K-20-2027, and PI 170757 showed notable resistance against the sesame leaf webber and capsule borer.

HORTICULTURAL CROPS

Crop Production

Crop load optimization in pomegranate variety Solapur Lal: The results revealed that light thinning (106-120 fruits/tree) of fruits resulted in optimum no. of fruits (116.8 fruits/tree), fruit weight (276.40 g/fruit) and optimum yield (32.28 kg/tree), which is superior over the control. The benefit: cost ratio was highest in light thinning (5.0:1), whereas it was lowest in control (3.89: 1).

Effect of 2,4-D on flower drop: Foliar application of the growth regulator 2, 4-D at six concentrations (5, 10, 15, 20, 25 and 30 ppm) at the onset of flowering and 7 days after anthesis was evaluated. The increase in concentration of 2, 4-D significantly reduced the flower drop. The growth regulator 2,4-D concentration @ 20 ppm was found to be highly beneficial for management of flower drop. Besides, 2, 4-D@ 20 ppm recorded the minimum flower drop (19.2 flowers/tree), percent flower drop (10.41%), and highest fruit set (58.38%) and number of fruits (96.50 fruits/tree) and highest yield (27.06 kg/tree). A higher concentration of 2,4-D above 20 ppm was not beneficial in enhancing the yield.

Control | Very light thinning | Light thinning

Medium thinning | Heavy thinning | Very heavy thinning

Crop land optimization in pomegranate var. Solapur Lal

Fertigation modules for high density planting in guava: The fertigation dose of 340: 70: 260 g N: P_2O_5: K_2O for HDP of 3 m × 2.5 m and 210: 40: 160 g N: P_2O_5: K_2O for HDP system of 2 m × 1.5 m was found optimum as it resulted in higher number of fruits per tree, fruit weight and fruit yield.

***In-situ* organic matter recycling in *Annona* hybrid Arka Sahan:** The *in-situ* organic matter recycling in Arka Sahan hybrid is efficient with recovery of 11-12 kg of microbial compost and 10.5-12.5 kg of vermicompost from pruned leaf biomass of 15-18 kg per tree. The nutrient analysis of compost indicated that vemicompost can supplement 167-199 g N, 19-23 g P and 62-74 g K and the microbial compost 156-170 g N, 11-12 g P and 63 to 68 g K per tree per year.

Bio-enriched organic manure production: Methodology for production of bio-enriched organic manure was standardized. The substrate combination cattle dung slurry (CDS) + poultry manure (PM) + coir pith (CP) (1:1:1 v/v ratio) with one kilogram of Arka Decomposer/tonne of feedstock was found superior with respect to pH, EC, CN ratio, macro and micronutrients and microbial counts.

Sustainable soilless growing media/substrate for terrace/rooftop/vertical gardening: Growing media of three different combinations using cattle dung slurry (CDS), coir pith (CP), poultry manure (PM), Arka Decomposer, Rock Phosphate (RP) and Arka Microbial Consortium (AMC) were evaluated for soilless cultivation of vegetables (radish and French bean) for promotion of terrace/roof top/vertical gardening in urban and peri-urban spaces. The substrate combinations (cattle dung slurry:coirpith:poultry manure @ 1:1:1 composted using Arka Decomposer and enriched with RP and AMC) resulted in better growth and yield in radish (1.245 kg per pot) and French bean (274.5 g per pot) without any external application of nutrients.

Technology for vertical expansion of nursery under protected conditions for clonal rootstocks of apple: A technology on the vertical expansion of the nursery was developed to utilize the available space in the greenhouse and to exploit the vertical growth of rootstock. Almost 100% results have been obtained in clonal rootstocks including (M9-Pajam, M-9-T337, M9-T339, MM-106, MM-111, B-9, P-22, and M-27) by using this technique. Technology involves the induction of wound followed by supplementation of suitable rooting media and phytohormones at specified time and position. Through this technology about four good quality (additional) rootstocks were obtained within one year and thus increases the multiplication rate significantly and saves the time. This technology has immense potential for commercialization and immediate adoption by the farmers due to its simplicity in operation and maximum returns.

Effect of citrus rootstocks on fruit quality: The growth, yield attributes, and juice quality parameters of Kinnow and Freemont mandarin fruits were significantly influenced by the rootstocks. Pectinifera rootstock was found to be superior with respect to quality parameters including juice percentage, total soluble solids (TSS), and significantly less acidity.

Effect of vermicompost on fruit quality of *ber*: The physico-chemical characters of ber cv. Gola were found to be superior with the application of vermicompost (20 kg/plant) + biofertilizers. It gave higher fruit diameter (3.42 cm), pulp fresh weight (22.25 g), TSS (26.55%) and vitamin C 212.50 mg/100 g. This treatment resulted in higher yield (14.90 kg/ plant), enzyme activity, i.e. dehydrogenase (8.15 µg TPF/g dry soil/h), alkaline phosphatase (8.25 µg p-NP g^{-1} dry soil h^{-1}) and urease (395 µg NH_3/g dry soil/h).

Effect of mulching on fruit quality of bael: Minimum fruit drop (94.10%) and sun scald (17.85%) with the highest fruit retention (5.50%) with grass mulch+NAA (15 ppm)+course cotton cloth in bael cv. Goma Yashi. The maximum fruit weight (1.35 kg), yield per plant (82.0 kg) and TSS (38^{o}B) was recorded in bael cv. Goma Yashi by maintaining canopy at 3 m plant height with pruning of 25% annual growth extension under rainfed semi-arid conditions.

Apical shoot cutting in *ker/kair*: The soilrite media was found suitable for vegetative multiplication of ker with respect to sprouting, rooting and growth of cuttings made from apical shoots. The success has been achieved in the vegetative propagation of *Cordia gharaf* through semi-hard wood cuttings using IBA and soilless media.

Pollination in date palm: Among the pollination methods of date palm cv. Halaway, pollen suspension and dusting pollination methods exhibited the maximum fruit weight (9.3 and 9.8 g), fruit length (38.1, 37.8 mm) and fruit width (19.6, 19.7 mm). The maximum number of fruit retention at pea stage was recorded in the cotton bud (27.0%) and dusting method (26.0%). The maximum fruit set was recorded in the pollen suspension (81.8%) followed by strand placement (79%) method. The pollen suspension method resulted in maximum bunch weight (7.5 kg/bunch).

Coconut-based farming system model standardized: Coconut-based farming system model in one ha at Kasaragod comprising coconut, black pepper trailed on the coconut trunk, banana in the border of the plots, fodder sorghum (CO 31- multi-cut fodder sorghum) in the interspaces of coconut along with a dairy unit, goat unit and poultry, achieved a net return of ₹ 5,43,682 and demonstrated high energy efficiency with an output of 884.9 KJ/ha. Intercropping multi-cut sorghum (CO 31) in coconut gardens with 100% organic nutrition yielded 79.9 t/ha of green fodder. Intercropping cinnamon in the coconut garden following the pentagonal method of planting (0.6 m × 1.2 m spacing with 5 plants per pit) recorded a significantly higher dry quill yield of 631.92 g $tree^{-1}$ and 979.0 kg/ha.

Management of boron in oil palm plantations under different soil types: Boron deficiency noticed in oil palm plantations may be due to inadequate fertilization, leaching or its adsorption in soils. Very little is known about the adsorption of nutrients in the soils of oil palm plantations. Adsorption kinetic models are essential in predicting the adsorption mechanisms, which helps in boron recommendation at appropriate doses. Different kinetic models were evaluated for the adsorption of boron in different soil orders in oil palm plantations. Considering the model parameters including coefficient of determination, the process by which the boron adsorbed to the soil is determined. Pseudo second order kinetic model was found to be best fitted model, which explains the chemisorption process involving sharing of electron between boron and soil. The data was subsequently investigated by an intra-particle diffusion model in order to gain reliable information about the phases involved in the adsorption mechanism. The model parameters help in suggesting the rate of boron application in oil palm in different soil types.

Efficacy of green manures in vegetable-based cropping system: Among different velvet bean genotypes, higher biomass (3.9 t/ha) was noticed in Arka Aswini and incorporation of crop residues of this genotype in vegetable cropping system resulted in maximum yield of *kharif* vegetables such as tomato (66.4 t/ha), chilli (32.7 t/ha) and okra (18.3 t/ha) and *rabi* vegetable crops, viz. French bean (18.90 t/ha), pea (9.08 t/ha) and Dolichos bean (11.90 t/ha). Among different velvet bean genotypes, the enrichment in SOC status was higher in Arka Aswini (10.14 g/kg) and varied from 8.43 to 9.76 g/kg in other genotypes such as Arka Daksha, Arka Shubra and Arka Dhanvantari.

Tomato: Based on nutrient removal and use efficiency data in tomato grown under protected conditions, the 125% estimated dose of fertilizers (EDF) yielded the highest overall yield and quality, including the best fruit size and weight, and the highest total soluble solids content.

Pea and French bean: Micromix C, named "Kashi Sookshma-Shakti Plus," a liquid formulation made using vermiwash as a base and mixture of essential micronutrients (Zn, Fe, Mn, Cu, B, Mo) and plant growth regulators (GA_3 and NAA), was evaluated for its impact on pea and French bean crop. It significantly enhanced the yield and quality, with increases of 13.39% in pea and 11.93% in French bean compared to controls.

Drip irrigation in okra: In a study on okra with drip irrigation and mulching, twice daily irrigation at 100% ET with Black-silver mulch yielded the highest fruit production (285.66 q/ha), 107.63% more than un-mulched furrow irrigation. Water-use efficiency peaked

Fish bone leaf | Crinkled leaf | Hook leaf | Blind leaf

Boron deficiency symptoms in oil palm

at 8.33 q/ha/cm with alternate day drip irrigation and Black-silver mulch.

Organic farming of okra: Application of 200 kg N/ha through microbial consortia enriched FYM recorded the highest yield of 109.12 q/ha. For optimizing productivity of broccoli under vegetable based organic farming systems combined application of FYM and vermicompost in 2:1 ratio to supply Nitrogen @ 150 kg/ha along with microbial consortia produced highest yield (183.19 q/ha) when grown in the plots receiving 200 kg N/ha through microbial consortia enriched FYM + vermicompost in preceding okra crop of the cropping system. This treatment resulted 12% higher yield over inorganic control. Under organic farming, okra-broccoli-bottle gourd cropping system recorded highest productivity with 200 kg N/ha through microbial consortia enriched FYM + vermicompost to okra and 100% recommended dose of nitrogen to the succeeding crops of broccoli and bottle gourd through FYM. The quality of vegetables, namely, bottle gourd, broccoli, and okra revealed significant superiority of organic produce in terms of ascorbic acid, TSS and dry matter. Natural farming, amaranth was successfully produced during *kharif* season with application of Jeevamrit, Ghanjeevaamrit and mulching producing yield to the tune of 30 tonnes/ha.

Nursery raising technology for vegetables in hot-arid region: Developed and validated a nursery raising technology for round the year vegetable seedling production in hot arid region. Cot-type iron frames were fixed on raised beds (50-60 m^2 plot area and a pair bed of 25 m × 01 m size). After seed sowing, the frames were covered with transparent polythene (120-200 gauge) and 40 mesh insect-proof nylon-net sheet during winter and summer season, respectively to get healthy seedlings.

Water saving techniques in cassava: Water saving techniques in cassava with drip irrigation at 50% CPE + ground cover sheet (120 gsm) (T_1) are recommended for adoption in the package of practices for Southern plateau and hill (Yethapur, Tamil Nadu). Water saving techniques in cassava with drip irrigation at 50% CPE + synthetic SAP (T_6) is recommended for adoption in the package of practices for East coast plains and hills (Peddapuram, Andhra Pradesh).

Development of "Pollinators on Flower Crops: A Database": Pollinator health is a vital element of managed and natural landscapes. Flourishing pollinator populations can promote healthy food systems and healthy ecosystems. Recently, pollinator decline has gained widespread public attention across the world. Wild bees and other pollinators are known to be very efficient pollinators of crop plants. For reversing pollinators decline, sincere efforts and efficient conservation strategies would be required to restore habitat and improve their health status. Ornamental flower crops have numerous species and very high levels of intra-specific diversity in terms of floral attributes, flower schemes, flowering time, floral rewards etc. Consequently, floricultural crops present an ideal, easily accessible, and cost-effective resource for pollinator foraging habitats. To facilitate this, it is imperative to gather information on pollinator diversity, their preferred floral sources, and comprehensive insights into their foraging ecology and habitats. This database includes the top 36 pollinator-friendly plants selected from a screening of 677 species/genotypes of ornamental plants comprising 184 genotypes of roses; 155 chrysanthemums; 88 gladioli, 36 tuberoses; 25 marigolds; 22 asters; 07 Jasmine; 58 water lilies; 58 annual flower crops; 14 perennial crops; 15 ornamental trees; 05 hedges; 05 edges; 03 creepers etc. This information will be updated regularly. The dynamic nature of this database is instrumental in offering essential details regarding the diversity, foraging ecology, and habitats of pollinators specifically on ornamental crops. Additionally, the database includes valuable information on various flowering plants, encompassing botanical knowledge and production protocols. Beyond raising awareness, this database stands as a pivotal resource for researchers and policymakers globally, providing a solid foundation for further studies and decision-making processes.

Nano urea application in turmeric and ginger: Foliar application of nano urea @ 0.4 % (two sprays at the active growth period of the crops, 90 and 120 DAP) for ginger and 0.2% for turmeric (two sprays at the active growth period of the crops, 90 and 120 DAP) along with 50% of the RDF N as soil application is recommended for higher N use efficiency and higher rhizome yield. The AE in nano urea (N) supplementation was higher by 10-15% than soil N application alone, indicating better use efficiency and yield in these nano N treatments. Spray of nano urea @ 0.4% as additional supplementation over the farmers practice has also resulted in 15% increased yield. The curcumin content of turmeric increased significantly with nano urea supplementation @ 0.2%. But the effect was not evidenced on the quality of ginger as there was no increase in its oil or oleoresin contents.

Coriander: The optimal yield of coriander variety ACr-1 (8.28 tonnes/ ha) was achieved with the treatment comprising 0.5 EC salinity, along with a combination of 50% FYM and 50% vermicompost supplemented by a foliar spray of micronutrient ($ZnSO_4$ @ 0.5%) and soil application of $FeSO_4$ @ 0.5%. The maximum yield of spinach variety Thar Hariparna was observed in the treatment of salinity 4 EC (IW)+100% NPK+FYM with a production of 202.15 q/ ha.

Crop Protection

Management of downy mildew and anthracnose diseases of grape: Grape downy mildew and anthracnose are major threats to *Vitis vinifera*, causing significant global losses. A study evaluated ICAR-NBAIM's microbe-based technologies—Kush Green Fungicide, Kush Eco-Pesticide, Kush Bio-Pulse, Kush Crop Care, and Kush Bio-Care 24—under organic viticulture systems at ICAR-NRCG, MRDBS, and two farmers' fields at Narayangaon and Junnar, Maharashtra. For downy mildew, Kush Bio-Pulse (@12 g/L) was most effective, with the lowest PDI (12.81) and highest PDC (69.77), followed by Kush Bio-Care (@12 ml/L, PDI (13.88), PDC (67.26). Other treatments also showed efficacy but with higher PDIs and lower PDCs. For anthracnose, Kush Bio-Pulse (@12 g/L) again performed best (PDI 17.63, PDC 45.87), followed by Kush Bio-Care (@12 g/L, PDI 18.25, PDC 43.95). Kush Green Fungicide (@12 g/L) recorded the lowest PDI (16.13) but moderate PDC (50.48) compared to the untreated control (PDI 32.56). All treatments significantly increased marketable yield over the untreated control (4.89 kg/vine). The highest yield was achieved with Kush Green fungicide (@12 ml/L, 11.42 kg/vine), followed by Kush Bio-Pulse (10.02 kg/vine) and Kush Bio-Care (9.86 kg/vine). These microbial technologies effectively controlled diseases, improved yield, and enhanced quality parameters across locations.

Management of powdery mildew in grapes: More than 60% of powdery mildew disease was managed by the *Trichoderma* and *Bacillus* formulations (MCBY-2, DRRS, and SB-5).

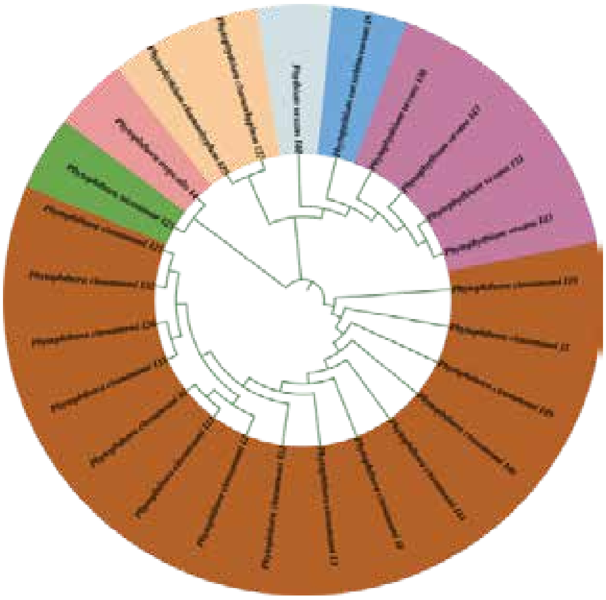
Simple diagnostic protocol for bacterial blight pathogen in pomegranate: An economical, simple, rapid, and culture-independent method was developed for routine analyses and detection of *Xanthomonas axonopodis* pv. *punicae* (Xap) that causes bacterial blight in pomegranate. Five DNA release buffers (B1-B5) were optimized for extracting bacterial genomic DNA (gDNA) directly from (a)symptomatic pomegranate leaves followed by conventional polymerase chain reaction (PCR)-based detection of Xap. B1, B3, and B4 were found suitable to release gDNA, which was subjected to PCR using universal primers for 16S rRNA and *rpsL* genes, and pathogen-specific xopQ primers. DNA released from B1 and B4 successfully produced amplicons of expected sizes.

Comparison of NRCB developed *Beauveria bassiana* strain with commercial formulation: Banana Weevil Killer® *(Beauveria bassiana* ICAR-NRCB Bb EPF 22) was compared with a commercial *B. bassiana* formulation at six different dosages against pseudostem weevil. Banana Weevil Killer® achieved 100% mortality of the pseudostem weevil at all six dosages compared, whereas commercial formulation showed a mortality range of 24–76%.

Diversity in banana bract mosaic virus: A banana bract mosaic virus has been documented and characterized for the first time from Andaman and Nicobar Islands on banana cv. Korangi. Based on the characterization of coat protein, HC-Pro and VPg region, isolate is found to be distinct compared to the previously documented BBrMV genome from India.

Etiology of avocado wilt disease: Main casual organism of root rot in avocado was identified as *Phytophthora cinnamomi* based on multigene phylogeny of Concatenating sequence analysis of *ITS1*, *beta tubulin* and *cytochrome oxidase I* genes.

Typical spindle shaped symptoms of BBrMV on sheath and mosaic on leaves



Phylogentic relationship of *Phytophthora* and *Phytophythium* species infecting avocado with other Genebank isolates (*ITS* region, *COX* 1 and β-*tubulin*)

Infected adult of RSW

R55-Morphology

Epizootics in RSW adults

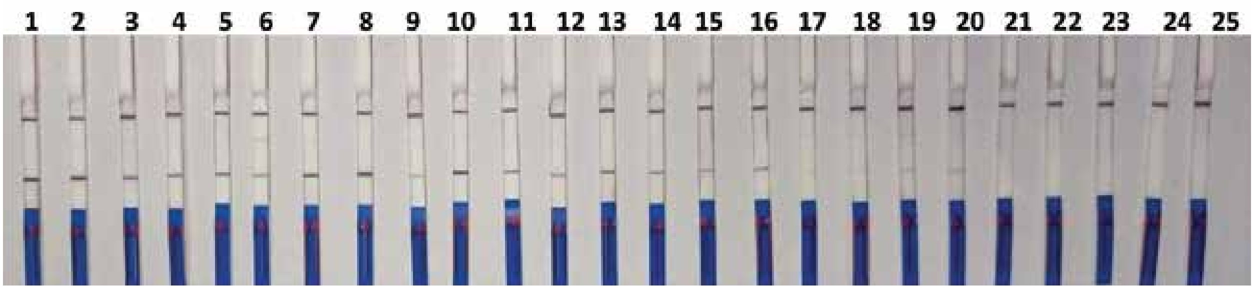
Rugose spiralling white fly of oil palm with infected with entomopathogenic fungus

Entomopathogenic nematode (EPN) strain effective against mango stem borer: Field evaluation of ICAR-IIHR strains of entomopathogenic nematode, *Steinernema* sp. against mango stem borer, *Batocera rufomaculata* indicated 80% reduction in stem borer infestation. EPN solution was injected into borer holes @ 10 ml/hole three times at five day intervals. Efficacy was at par with standard check insecticide.

Effect of pre-harvest spray of *Bacillus subtilis* on shelf-life of litchi: Pre-harvest spray of *B. subtilis* has shown promise with regard to improving shelf-life. Spray formulation of BS-01 was supplemented with trehalose. Spraying of trees were done two days before harvest having 10^6 cfu/ml in spray solution which was compared with control, i.e. water spray. After two days, fruits were harvested and stored in aerated polythene bags. The mean percent fruit decay was 0.00 at 4th day of storage at ambient temperature and at 20th day of storage at 4°C in BS-01 treated fruits. On 6th day of storage at ambient temperature, the percentage of fruit decay was 20 and 7.8 in BS-01 treated fruits as compared to 100 and 76.7 in control fruits in 2022 and 2023, respectively. Mean percentage of browning of fruit was 0.00 in BS-01 treated fruits on 2nd day of storage at ambient temperature and at 20th day of storage at 4°C. Mean value of anthocyanin decreased with increase in storage period at both temperatures but the rate of decrease was lower in BS-01 treatment fruits as compared to control. Thus, studies conclusively proved that pre-harvest spray of *B. subtilis* (NRCL BS-01) enhanced shelf-life and fruit quality of litchi. An *in-vitro* study was conducted to evaluate antagonistic activity of *B. subtilis* strain BS-01 against pathogen (*Alternaria alternata* and *Fusarium solani*) and safety to biocontrol agent (*Trichoderma viride* NRCLT01). Results showed that *B. subtilis* strain BS-01 effectively inhibited the litchi pathogens *A. alternata* and *F. solani* while the biological control agent *T. viride* was least affected by it.

Standard Operating Procedure (SOP) for spraying with UAV in coconut palms: The Standard Operating Procedure (SOP) for spraying with UAV in coconut palms was optimized. Spraying using jet nozzle, spray distance of 1 m height and hovering for 8-11 sec over a coconut palm are the standard parameters for effective coverage. Among the diverse whiteflies, *Paraleyrodes bondari*, followed by *Aleurodicus rugioperculatus* and to limited extent by *Aelurotrachelus atratus* were currently recorded on coconut palms with complete displacement of *A. disperses* as well as *P. minei* in coconut system. Morphometric characters of different stages of palm whitefly *Aleurotrachelus atratus* and its molecular identification was established. An entomopathogenic fungus (EPF), *Simplicillium lanosoniveum* isolated from the nymphal cadavers of rugose-spiraling whitefly was found virulent and pathogenic to all the developmental stages of RSW and cost-effective bioformulations were evolved.

Management of rugose-spiraling whitefly using entomopathogenic fungus isolate: The entamopathogenic fungus (R55) isolated from native soils of oil palm plantations was found to be highly lethal (100% mortality) against adult stages of RSW. The isolate is able to cause epizootics under favourable climatic conditions. Multilocation field evaluation showed > 96 % reduction in RSW population. No lethal effects were observed against pollinating weevil and *Encarsia*. ICAR-IIOPR developed low cost mass production technology for multiplying the isolate.



Field performance of RPA-LFA: 1-5: Healthy palms; 6-10: Asymptomatic palms; 11-20: Palms with skirting; 21-25: Palms with brackets

Development and validation of early and point-of-care detection of *Ganoderma*-induced basal stem rot in oil palm: Recombinase Polymerase Amplification-Lateral Flow Assay (RPA-LFA) was developed for the onsite and early detection particular to *Ganoderma* at asymptomatic phase. The RPA reaction conditions were standardised/optimised with respect to concentration of magnesium acetate, betaine concentration, incubation temperature as well as incubation time. The assay was validated by analysing fungal pure DNA, plant pure DNA, and crude DNA extracted from palms showing varying degrees of disease severity, collected from different sampling sources including soil, stem, and roots. The detection system could detect *Ganoderma* with crude DNA extracted from asymptomatic palm roots. The method was highly sensitive, detecting as little as 10 $pg\mu L^{-1}$ of *Ganoderma* DNA at 41°C in 30 min. This assay is highly specific to *Ganoderma* and was validated across 10 different species of *Ganoderma.* Further, there was no cross reaction with 10 other oil palm associated microbes/pathogens. The kit was further validated across 55 field infected samples from different locations.

IPM in vegetable crops: In integrated insect pest management of major vegetable crops for safer vegetable production, the biology of radish root and shoot hole borer *Phyllotreta striolata* was studied on radish. Further, in virulence assay, *Heterorhabditis indica* found as a potential entomopathogenic nematode against both third instar and pre-pupal stages of *P. striolata*.

Grubs of radish flea beetle on the rhizosphere

Residue analysis of pesticides: In residue analysis and risk assessment of pesticides in vegetable crops, different methods were evaluated to decontaminate Deltamethrin residue from tomato, okra, bitter gourd, cowpea, and chilli. In integration of compatible components to develop crop-specific module for the insect-pest and disease management (IPDM) in vegetables, effect of insecticide, i.e. Flupyradifurone and Imidacloprid exposure on honey bees, *Apis mellifera* has been studied. The survival of bees exposed to flupyradifurone was 90%, whereas the survival of bees exposed to imidacloprid was 40%.

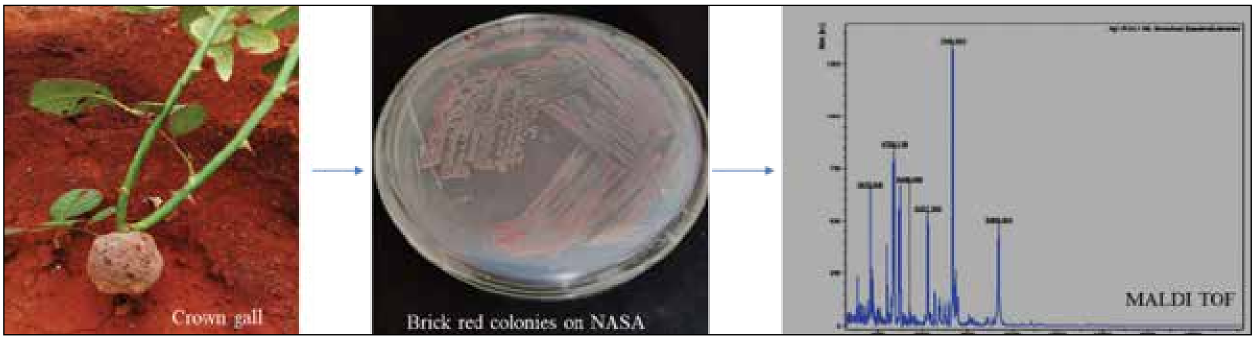
Disease management in potato: The occurrence of self-fertile (Homothallic) isolates of *Phytophthora infestans* were observed in potato fields. Epidemiological studies revealed that self-fertile isolates are equally competitive with A1 and A2 mating types thus posing a serious threat to late blight management. Isolates of *P. infestans* had shown insensitivity towards cymoxanil indicating that the pathogen is acquiring resistance towards cymoxanil based fungicide which is cause of concern to all potato stakeholders.

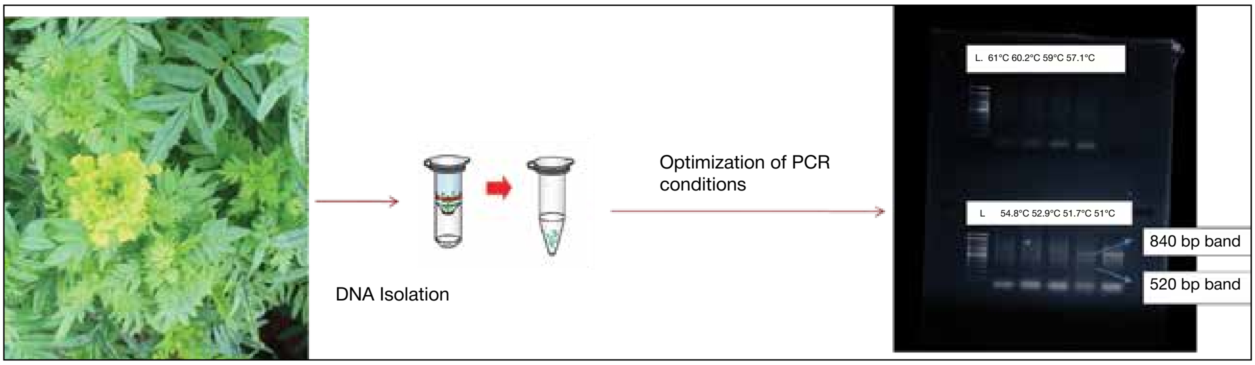
Molecular characterization of *Streptomyces* isolates: Molecular characterization of *Streptomyces* isolates yielded about a dozen diverse species *S.* Development of common scab could occur under wide range of soil pH (4.0 to 9.0); however, a gradual increase in common scab severity was also observed with an increase in soil pH. No significant role of soil moisture was observed in the development of common scab. ClO_2 (0.3%) was observed most effective and almost completely inhibited the growth of *S. scabiei*, followed by NaOCl, whereas boric acid was least effective.

Disease forecasting: Indo-Blightcast Model predicted appearances of late blight well in advance across agro-ecologies and accordingly agro-advisories were issued for its management. A robust one-step Reverse Transcription Recombinase Polymerase Amplification (RT-RPA) assay has been developed for rapid detection of Potato virus A (PVA). Studies on biosafety evaluation of Late Blight resistant GE potato KJ 66 for environmental release revealed high level of late blight resistance in KJ 66. The data on pests and disease incidence suggest that susceptibility level of GE potato KJ 66 was similar to all other tested conventional non-transgenic counterparts and checks and did not show any enhanced incidence of pests and diseases.

***In-vitro* screening of potato germplasm against scab disease:** A novel tissue culture-based method was developed for *in-vitro* screening of potato germplasm against common scab disease. The method is quick, simple and feasible in lab and the symptoms on micro-tubers develop within 7-10 days of inoculation. Screening of varieties (27) against common scab by this method revealed that none of the tested varieties has resistance to this disease. Isolation, identification, and assessment of pathogenicity of entomopathogenic fungus (*Akanthomyces dipterigenus*) infecting *Myzus persicae*, suggests its potential as a microbial control agent against *M. persicae*.

Efficacy of various cropping systems to control nematode population: Results of different cropping systems highlighted the efficacy of specific crop rotations in reducing PCN populations, with combinations like Oat-Mustard-Mustard-Trap showing promising results. Additionally, the discovery of millet and cereal root leachates as new hatching factors for PCNs provides valuable insights into potential alternative control methods.



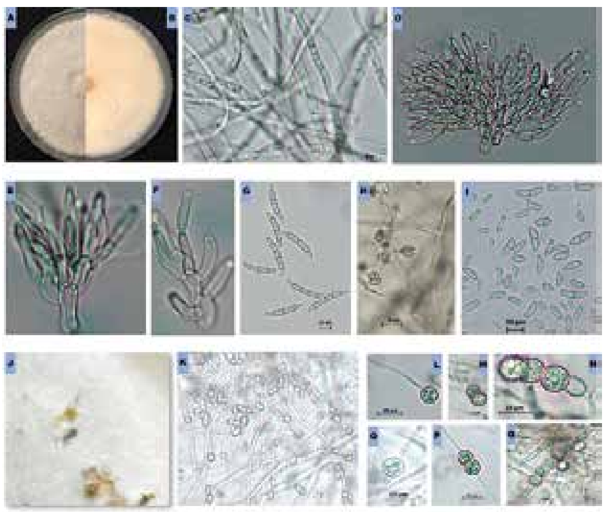


Isolation of bacterial pathogen associated with crown gall in rose and identification using MALDI TOF method: Isolation of pathogen was done on Clark's Selective Medium (NASA). NASA is a selective media for the isolation of *Agrobacterium tumefaciens*, which gave brick-red colonies after 72 h of incubation. Gram staining showed gram negative rods. Using MALDI TOF method, based on a 2.022 match score with a Spectra indicating the protein profile of 2-20 KDa, pathogen identified as *Rhizobium radiobacter* (*Agrobacterium tumefaciens*).

Development of duplex PCR for simultaneous detection of phytoplasma and begomovirus from marigold: A duplex PCR method was optimized with DNA templates of begomoviruses and phytoplasma DNA using Deng A and B primers for Begomovirus and SecA primers for phytoplasma. The optimized reaction conditions are initial denaturation at 94^0C/2 min, later denaturation at 94^0C/30 sec and annealing at 51^0C/30 sec and extension of 72^0C/1 min for 40 cycles where the expected amplicons of ~520 and ~840 bp has been generated.

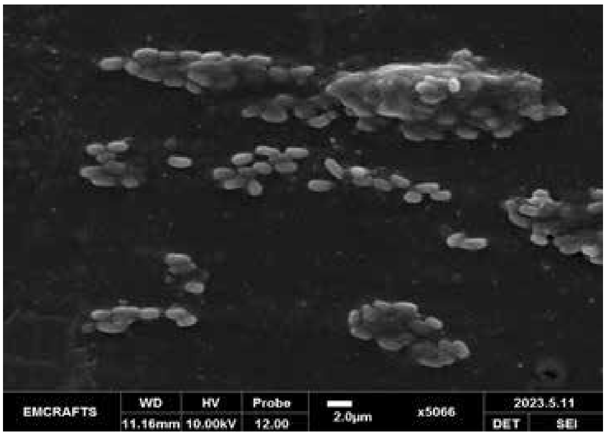
Characterization and management of *Spathiphyllum* wilt: The pathogen was identified as *Fusarium falciforme* using polyphasic approach which include morphological, multi-gene sequencing and pathogenicity assay. The isolate was designated with the name as *F. falciforme* isolate SP-Ff-Kd. Pathogenicity assays in 30-days-old *Spathiphyllum* plants demonstrated that yellowing of leaves was observed seven days after pathogen inoculation using a non-invasive method, followed by complete wilting of the plants within 15 days. In addition, host range analysis revealed that the *F. falciforme* isolate SP-Ff-Kd isolated from wilted *Spathiphyllum* plants could cause complete wilting within 12-15 days post-inoculation in other economically important solanaceous crops such as

Development of symptoms in *Spathiphyllum* infected with *F. falciforme*



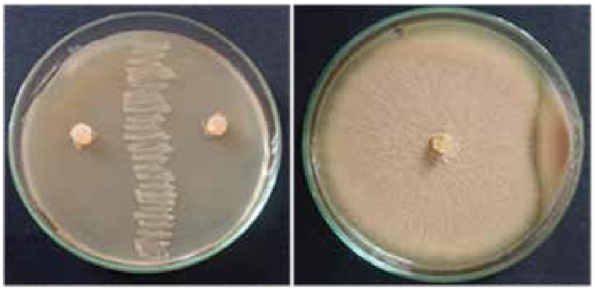
Morphological and microscopic characteristics of *F. faclciforme* isolate SP-Ff-Kd tomato, brinjal, chilli and tobacco, further highlighting its economic significance. Studies evaluating different fungicides revealed that root zone application of carbendazim 50% WP at 1 g/L and tebuconazole 25.9% EC at 1 ml/l were effective in controlling wilt incidence, achieving 77.78% reduction as a prophylactic treatment and 66.67% reduction as a curative treatment.

Identification and characterization of lignocellulolytic bacteria: Eleven dominant lignocellulolytic bacteria were isolated from the compost and casing of button mushroom (*Agaricus bisporus*) and studied for their ability to degrade wheat straw, their antifungal and yield-enhancing activities in button mushroom. The bacterial isolates were identified as *Bacillus subtilis* (BSB1, BSB3, BSB5 and BSB13), *Paenibacillus polymyxa* (PPB6), *Bacillus* sp. (BB7), *B. cereus* (BCB8 and BCB12), *Alcaligenes faecalis* (AFB11), *Acinetobacter johnsonii* (AJB15/B) and *Pseudomonas aeruginosa* (PAB16/P) by 16S rRNA sequencing. All the tested bacterial isolates showed antagonistic activities against *M. perniciosa* compared with the control. PAB16/P resulted in the greatest growth inhibition of *M. perniciosa* (91.89%), followed by BB-7 (76.39%). The other isolates, BSB1, BSB3, BSB5, PPB6, BCB8 and BSB13, inhibited the growth of *M. perniciosa* by 61.11 to 72.55%. The degradation of wheat straw via six microbial consortia (MC-1 to MC-6) was studies on the basis of CO_2 release after 15 days of incubation. Among all the microbial consortia, the highest CO_2 release (174666.70 ppm) was recorded



Dominating genus *Bacillus*

Infected and healthy fruiting bodies



Antifungal activities of PAB16/P

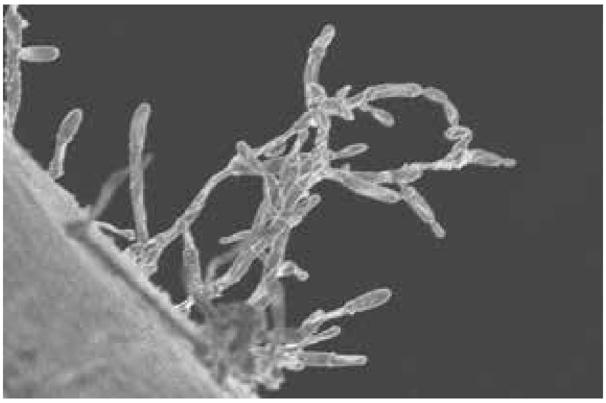
Antifungal and growth promoting activities of lignocellulolytic bacteria

in MC-3 (combination of PAB16/P, AJB15/B, AFB11 and BSB5) compared with the control (sterilized water), which exhibited a CO_2 release of 43,166.60 ppm. Additionally, an apparent colour change was observed in straw treated with MC-3, and no contamination was observed in the straw. Compared with the control, compost inoculated with MC-3 produced the highest crop yield (16.20 kg/100 kg substrate) (12.84 kg/100 kg substrate). According to the present investigations, MC-3 may be recommended for the fast breakdown of cellulosic materials during the preparation of button mushroom compost for the management of wet bubble disease and to increase crop yield.

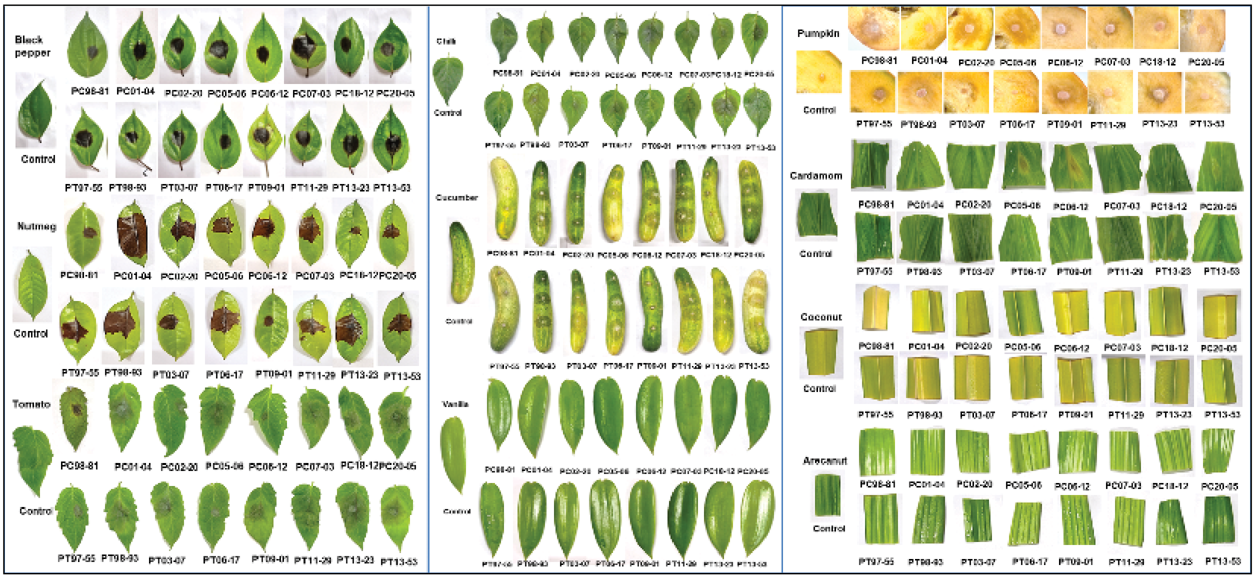
A new species of entomopathogenic fungus, *Metarhizium indicum* from India: A new species of entomopathogenic fungus, *Metarhizium indicum* sp. nov. which derives its species name after its Indian origin was found to induce epizootics in garcinia leafhopper, *Busoniomimus manjunathi.* The fungus was found to cause more than 60% mortality under field conditions. The new species was characterized based on its distinct morphological features and multi-gene analyses. Phylogenetic analyses with internal transcribed spacer region (ITS), DNA lyase (APN2) and with a concatenated set of four marker genes [translation elongation factor 1-alpha (TEF), β-tubulin (BTUB), RNA polymerase II largest subunit (RPB1) and RNA polymerase II second largest subunit (RPB2)] along with marked differences in nucleotide composition and genetic distance unambiguously support that the fungus is a new addition to the *Metarhizium* taxa infecting leafhoppers.

Complete genome sequence of a divergent strain of cardamom mosaic virus: Cardamom mosaic virus (CdMV; genus *Macluravirus*), which causes mosaic (*katte*) disease in cardamom, is a highly variable member of the family *Potyviridae*. The complete genome sequence of a CdMV isolate from Kerala consists of 8,255 nucleotides (nt) with two open reading frames (ORFs). The large ORF, potentially coding for a polyprotein of 2,638 amino acids (aa), is further proce-ssed into nine mature proteins at eight cleavage sites. The second ORF starting with a C(A)6 motif, encodes a small protein of 56 aa. The viral genome contains an additional 13 nt in the 5′ untranslated region (UTR) and

Leafhopper infected by *Metarhizium indicum*



Scanning electron micrograph of the developing phialides and conidia of the fungus on the insect host



Cross infectivity assay of black pepper *Phytophthora* isolates on nutmeg, tomato, chilli, cucumber, vanilla, pumpkin, cardamom, coconut and arecanut (PC and PT denotes *Phytophthora capsici* and *P. tropicalis*, respectively)

6 nt in the CP gene, as well as a deletion of 13 nt at the 3′ UTR in comparison to the Karnataka (KS) isolate of CdMV. The complete viral genome and polyprotein share 76% and 85% sequence identity with the Karnataka isolate of CdMV, indicating that the present isolate is highly divergent from the Karnataka isolate.

Effect of arbuscular mycorrhizal inoculation on black pepper cuttings: Single-node cuttings of black pepper inoculated with arbuscular mycorrhiza (AM) showed significantly higher mycorrhizal root colonization (95%) and spore numbers. AM fungi had a more pronounced effect on improving root biomass compared to above-ground biomass. Inoculated plants exhibited enhanced nutrient uptake and higher acid phosphatase and dehydrogenase activity. Additionally, the net photosynthetic rate and stomatal conductance of AM-colonized black pepper leaves were significantly higher than those of uninoculated plants. Early-stage AM inoculation improved symbiosis and plant growth in the nursery, potentially enhancing field performance after planting.

Cross-infectivity analysis of *Phytophthora* isolates from black pepper on other crops: Eight isolates each of *P. capsici* and *P. tropicalis* from black pepper were tested for cross-infectivity. All 16 isolates could infect nutmeg, tomato, chilli, pumpkin, and cucumber. A few isolates were also able to infect cardamom. However, none of the isolates were able to infect coconut, arecanut, or vanilla.

Multiplex PCR for simultaneous and rapid detection of viruses (ApMV, ApNMV, ASGV and ASPV) in apple: A cost-effective, rapid, and accurate m-RT-PCR method was standardized to detect four apple viruses: ApNMV, ApMV, ASPV, and ASGV. Four specific primer pairs produced amplicons of 670, 550, 350, and 210bp, corresponding to ApNMV, ApMV, ASPV, and ASGV, respectively, when tested individually. The m-RT-PCR allowed simultaneous detection of all four viruses in a single tube. The protocol was validated on seven symptomatic and asymptomatic apple cultivars, revealing the presence of 1 to 4 viruses. ApNMV and ApMV were associated with 6 symptomatic cultivars, either alone or in mixed infection, while ASPV was detected in 6 out of 7 cultivars, including the asymptomatic one.

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Livestock Improvement

ICAR's advancements in livestock breeding, reproductive technologies, and genetic improvement continued resulting in significant progress in enhancing milk production, animal health, and breeding efficiency across various species in India. The synthetic Frieswal cattle breed, capable of producing 7,000 kg of milk per lactation, was developed by ICAR-CIRC, Meerut, and registered with ICAR-NBAGR, Karnal. The Frieswal female calf was successfully produced through OPU-IVF-ET in collaboration with ULDB, using a Sahiwal recipient cow. Genetic improvement programmes for Gir, Kankrej, and Sahiwal breeds led to a significant increase in milk yield (53.71%) and a reduction in age at first calving (16.73%) across 16 sets from 2010 to 2023. ICAR achieved milestones in genome editing, including the birth of an MSTN knockout calf with enhanced muscle traits and advancements in producing sex-predetermined embryos via CRISPR technology. Cloned bulls on evaluation showed comparable performance to non-cloned counterparts. A buffalo bull fertility chip was developed to identify and eliminate sub-fertile bulls from breeding programmes. Recombinant FSH and LH hormones for buffaloes were produced and their identity validated through LC-MS/MS. Innovative estrus detection methods using saliva crystallization patterns were explored. The 305-day lactation yield in Murrah buffaloes reached a record 2,665 kg in 2023-24, reflecting a 66.35% improvement since the project's inception. The Network Project on Sheep Improvement covered 146 breeders with 13,832 sheep, including 9,256 breedable ewes, in Madras Red and Magra field units. A Kisspeptin analogue for estrus synchronization in sheep, goats, and other ruminants was synthesized. A mobile Artificial Insemination laboratory (Avi MAIL) was developed to enhance large-scale sheep breeding programmes and field adoption of AI technology. The AICRP on Poultry Breeding distributed 10,40,567 chicken germplasm to 14,113 beneficiaries across multiple centres. Evaluations included native, crossbred, and specialized chicken populations (e.g. Mewari, Kamrupa, Himsamridhi, and Tokbari). A new crossbred pig variety, Goya, was developed by the ICAR-NRC on Pig and ICAR-Coastal Agricultural Research Institute, Goa, for coastal region propagation.

Cattle

Synthetic cattle breed 'Frieswal': The ICAR-Central Institute for Research on Cattle (CIRC), Meerut, in collaboration with Uttarakhand Livestock Development Board (ULDB) successfully produced a healthy 'Frieswal' female calf using the cutting-edge technique of Ovum Pick-Up *in vitro* Fertilization-Embryo Transfer (OPU-IVF-ET) from a recipient Sahiwal cow. 'Frieswal,' is India's first synthetic cattle breed. This breed can produce approximately 7,000 kg of milk per standard lactation, with a peak yield of about 41 kg per day. Frieswal is acclimatized to all agro-climatic regions of the country, making it a valuable addition to the Indian dairy industry. It is the first synthetic breed to be registered with ICAR-National Bureau of Animal Genetic Resources (NBAGR), Karnal.

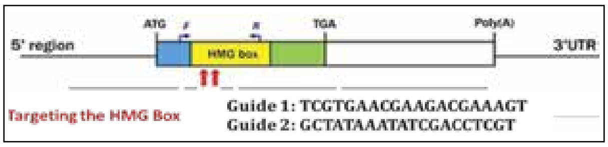
Frieswal, a synthetic cattle breed developed by ICAR-CICR

Genetic improvement of cattle breeds through progeny testing: Three indigenous cattle breeds, viz. Gir, Kankrej, and Sahiwal, are being improved through the selection of elite animals maintained at germplasm units (GPs) and associated herds (AHs), including farmer herds. The Field Progeny Testing programme has been implemented across four units, viz. GADVASU, Ludhiana, Punjab; KVASU, Thrissur, Kerala; BAIF, Pune, Maharashtra; and GBPUAT, Pantnagar, Uttarakhand, covering diverse agro-climatic regions of the country. A total of 5.32 lakh inseminations were carried out using 359 bulls across 16 sets, resulting in the birth of 69,001 female progenies. The programme has demonstrated significant progress. Average milk yield per lactation increased from 2,494.8 kg in the first set (2010) to 3,834.76 kg in the 16th set, reflecting a substantial rise of 1,339.96 kg (53.71%). Additionally, the age at first calving decreased from 1,149 days in the first set (2010) to 956.7 days in the 16th set, showing a reduction of 192.3 days (16.73%).

Buffalo

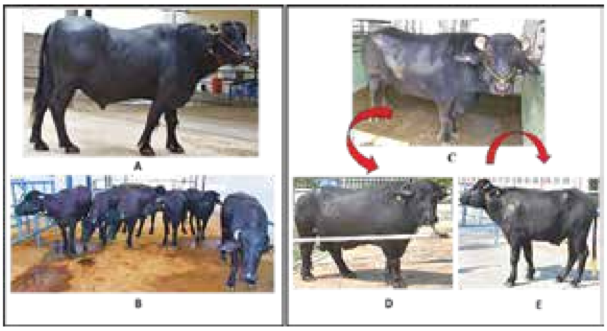
Production of gene knockout buffalo calf: CRISPR/Cas9-mediated knockout of the MSTN gene in buffalo fibroblasts, combined with somatic cell nuclear transfer (SCNT) and embryo transfer, led to the birth of a Myostatin (MSTN) knockout calf with increased muscle fiber diameter. This achievement highlights the potential of genome editing to enhance production traits in buffalo.

Generation of sex determined buffalo embryos using CRISPR mediated gene editing technology: Sex-determining Region Y-knockout (SRY-KO) embryos were successfully generated by electroporating Ribonucleoprotein Complexes (RNPs) targeting the High Mobility Group (HMG) domain of the SRY gene at a single stage using an optimized protocol. Mutations in the SRY gene altered its functional properties and its interaction network with other genes, including Sox9, Foxl2, β-catenin, Amh, FGF9, PGD2, WNT4, and DMRT1, as revealed by *in-silico* analysis.



Targeting the HMG domain of SRY gene

Evaluation of semen characteristics and fertility parameters in cloned bulls and performance of clone's progenies: The ICAR-Central Institute for Research on Buffalo (CIRB), Hisar, conducted a comprehensive evaluation of postnatal growth, hematology, telomere length, and semen attributes in multiple clones and re-clones derived from superior buffalo breeding bulls. No significant differences were observed in these parameters between the cloned calves and non-cloned bulls.

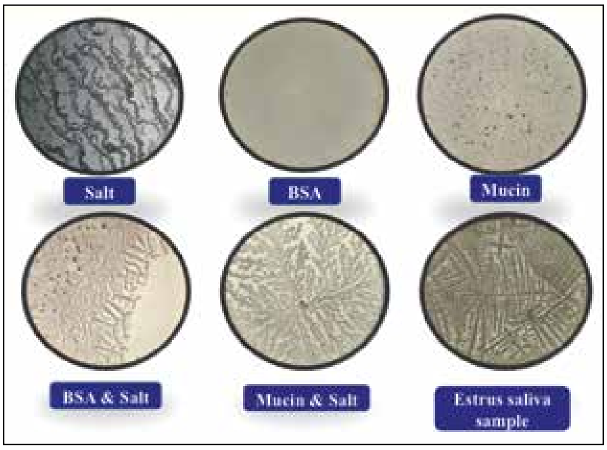


Evaluation of cloned bulls. (A) Donor bull M29; (B) Seven clones (E-263-269) of M29 at one year of age; (C) Donor bull M4354; (D) Clone (M4998) of M4354 produced earlier in 2015, and (E) re-clone (E-270) of cloned M4998 at one year of age.

Development of buffalo bull fertility chip: Unique single nucleotide polymorphisms (SNPs) associated with high and low fertility were identified in buffalo bull spermatozoa by the ICAR-National Institute of Animal Nutrition and Physiology (NIANP), Bengaluru. These SNPs can serve as diagnostic markers to identify and eliminate sub-fertile bulls from Artificial Insemination Programmes.

Recombinant FSH and LH hormone production: ICAR-NIANP successfully produced buffalo FSH and LH hormones indigenously and expressed the recombinant α and β chains of buffalo LH. The identity of the expressed peptides was confirmed through LC-MS/MS analysis.

Simulating typical fern-like patterns of buffalo saliva at estrus with mucin and salt combination: Detecting estrus in buffaloes, especially during the summer, is challenging due to the visibility of traditional estrus signs. A novel approach to overcome this deficit was developed that involves identifying fern-like crystallization patterns in saliva, which are hypothesized to be linked to estrus-specific mucins and salts.



Comparison of different combinations of salts, glycoproteins, and natural buffalo saliva at estrus

Sheep

Network Project on Sheep Improvement: A total of 146 sheep breeders, managing 13,832 sheep, including 9,256 breedable ewes, were involved in performance recording and improvement efforts in the Madras Red and Magra field

Mobile Artificial Insemination Laboratory (Avi MAIL)

For conducting large-scale sheep breed improvement programmes and to make AI technology acceptable in the field, a mobile Artificial Insemination laboratory (Avi MAIL) was designed, fabricated and developed as a model.

Genetic resources of sheep

Sheep maintained in Field Units				Genetic resources of sheep maintained in farms			
Details	Madras Red Unit	Magra Unit	Total	Breed	Rams (no.)	Ewes (no.)	Total (no.)
No. of sheep breeders	81	65	146	Marwari	191	360	551
No. of sheep registered	7,230	6,602	13,832	Muzaffarnagri	133	326	459
No. of breedable ewes	4,870	4,386	9,256	Deccani	106	284	390
No. of animal identification	2,115	2,346	4,461	Nellore	107	267	374
No. of performance recording	4,875	1,436	6,311	Mandya	82	322	404
No. of health coverage	69,046	13,580	82,626	Mecheri	134	428	562
				Sonadi	62	291	353
				Malpura	201	389	590

Sonadi (*top*) and Muzaffarnagari (*bottom*) rams

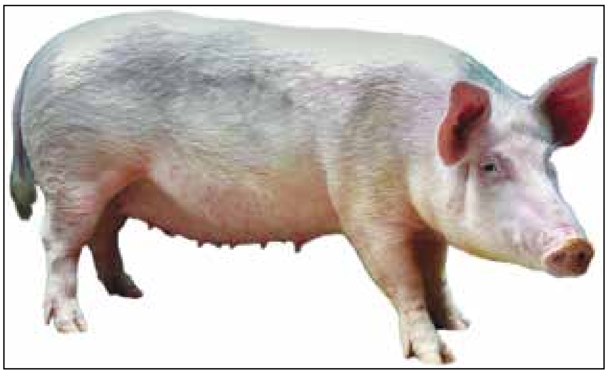
units. Together, these units identified 4,461 new animals, recorded 9,856 performance data points, and provided health coverage for 82,626 animals.

Synchronization of estrus in sheep, goat and other ruminants: A new peptide synthesized (Kisspeptin analogue) and developed by ICAR-NIANP can be used as a potential therapeutic agent for induction/ synchronization of estrus in sheep, goat and other ruminants.

Poultry

AICRP on Poultry Breeding: A total of 10,40,567 chicken germplasm were distributed to 14,113 farmers and beneficiaries across various centres. The Mannuthy centre evaluated the S-34 generation of IWN and IWP strains of White Leghorn. At the AAU, Anand centre, the native Ankleshwar breed and White Leghorn strains were assessed. The Bengaluru and Ludhiana centres focused on evaluating PB-1 (male line), PB-2 (female line), and native chicken populations. The MPUAT, Udaipur centre conducted evaluations of the Mewari and Pratapdhan populations. The AAU, Guwahati centre assessed the Kamrupa variety, indigenous chicken populations, and Dahlem Red strains. Performance evaluation of the Himsamridhi breed was carried out at the Palampur centre, while the Jabalpur centre focused on the G-3 population of the Jabalpur colour variety and the Kadaknath breed. The Agartala centre assessed Tokbari, a newly developed location-specific chicken variety for the NEH region.

AICRP unit of ICAR-NRC on Pig: A new crossbred variety of pig, i.e. Goya was released at ICAR-Coastal Agricultural Research Institute, Goa for propagation in coastal areas.



Crossbred pig variety 'Goya'

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5. Livestock Management

Advancements in livestock health, genetics, and disease management led to significant breakthroughs in livestock management in various Animal Science institutes of ICAR. CARI-Toxomin, a herbal toxin binder, protects poultry feed from mycotoxins, replacing inorganic binders. CARI Boost improves broiler growth and immunity while CARI Egg Shield extends egg shelf-life. Mitochondrial dysfunction linked to retained placenta in crossbred cattle was identified, with altered gene expression and reduced complex I activity, potentially affecting placental expulsion. Positive selection in MHC genes important for immunity and disease resistance across 15 indigenous dairy cattle populations was recorded. Milk exosomes (mEs) were explored as drug delivery vehicles, improving mastitis treatment by encapsulating ampicillin for enhanced efficacy. Green nano-antibacterial technology and nano-minerals were developed to combat multi-drug-resistant bacteria in poultry. An AI-based system using CNNs was developed for diagnosing parasitic infections in Mithun. A novel bilateral fixator and circular ESF was developed for flexible treatment of open fractures. NADRESv2 generated over 5,600 risk predictions for livestock diseases, issuing 17.5 million SMS alerts in Karnataka. Sero-surveillance for One Health diseases like Leptospirosis was conducted, with 120 positive samples. An indigenous BVDV-1 vaccine provides immunity for 12 months, while a live-attenuated LSD vaccine showed high seroconversion and no adverse effects. Diagnostic tests for FMDV, SARS-CoV-2, and PCV3 were developed, with high sensitivity and specificity. A competitive ELISA for Canine Distemper Virus and a rapid assay for ESBL production in bacteria were also developed. Early detection kits for LSD were released. A national sero-surveillance for FMD tested 49,481 serum samples, revealing 16.7% bovine seropositivity. Post-vaccination samples showed improved protection against FMD serotypes. A negative marker trivalent FMD vaccine, developed using reverse genetics, demonstrated protection similar to the wild-type vaccine. Capsid sequencing identified vaccine mismatches, guiding better-targeted vaccines. Thermostable FMDV strains were selected for harsh climates. Sensitive RT-LAMP and TaqMan RT-qPCR assays were developed for high-throughput FMDV diagnostics. Glanders surveillance identified 33 positive cases in 22,756 equine samples. Genetic analysis of LSDV outbreaks revealed possible exotic introductions, with indigenous Rathi cattle showing stronger immunity than crossbred cattle.

Nutrition

Herbal initiative for mycotoxin control (CARI-TOXOMIN): ICAR-Central Avian Research Institute (CARI) has developed 'CARI-Toxomin', a herbal toxin binder designed to protect feed and feed ingredients from toxins. Made from locally available herbal ingredients, it contains gallic acid, ascorbic acid, phenolic compounds, curcumin, and enzymes. It effectively reduces toxicity in broiler chicken feed by up to 90%, offering a cost-effective alternative to expensive inorganic toxin binders available in the market.

CARI Boost: This agro-waste based formulation added to broiler chicken diet is an effective growth promoter and can act as an alternative to antibiotic growth promoters. It improves growth performance, enhances immune response, supports gut health, and reduces stress in broiler chickens (*Source*: ICAR-CARI, Izatnagar).

CARI Egg shield: This innovative solution, when applied as a single spray to the outer surface of eggs, creates a barrier that prevents external microbes from entering and provides significant benefits to the poultry industry by extending the shelf-life of table egg up to 24 days in ambient temperature and >60 days in refrigerated temperature.

Nano-minerals as poultry feed: Nano copper, nano zinc, and nano selenium were produced using green synthesis methods involving plant materials. Supplementation of nano zinc and nano copper at 50% of the recommended level in broilers enhanced zinc retention and humoral response. Additionally, while nano zinc improved meat quality, nano copper did not have the same effect.

Physiology

Association between mitochondrial alterations and retained placenta in crossbred cattle: Retention of placenta (RP) in crossbred cattle poses health, reproductive, and economic challenges linked to oxidative stress and hormonal imbalances. A study explored differences in oxidative phosphorylation (OXPHOS) activity, mitochondrial content, and mtDNA gene expression between normal and RP cases. RP tissues showed reduced OXPHOS complex I activity, lower transcript levels for most mtDNA-encoded protein genes, and increased ND6 expression, while mtDNA copy number differences were not significant. Mitochondrial abnormalities may affect energy supply, hormonal balance, and oxidative stress, influencing placental retention. These findings offer insights into RP mechanisms and provide a model for studying placental insufficiency.

Identification of unique signatures of selective sweeps in indigenous dairy cattle breeds: The Major Histocompatibility Complex (MHC) genes are vital for adaptive immunity and have been extensively studied in vertebrates for their role in immune responses to infectious diseases. This analysis revealed potential positive selection signatures in specific MHC-associated genes, despite the general understanding that many MHC genes are primarily maintained through balancing selection. The most notable regions under selection included BOLA, non-classical MHC class I antigen (BOLA-NC1), Microneme protein 1 (MIC1), Cluster of Differentiation 244 (CD244), and Gap Junction Alpha-5 Protein (GJA5).

Milk exosomes (mEs) as drug delivery vehicles for mastitis treatment: Mastitis, a significant dairy industry problem, is increasingly difficult to treat due to antibiotic resistance. Use of milk exosomes (mEs) as drug delivery vehicles to enhance antibiotic efficacy against *Staphylococcus aureus* was studied. By encapsulating ampicillin within mEs, a more effective treatment, mEs-AMP was developed, which demonstrated superior antimicrobial and therapeutic properties compared to traditional ampicillin treatment in both *in vitro* and *in vivo* models of mastitis.

Livestock protection

External skeletal fixation (ESF) for management of fractures in animals: External skeletal fixation is a minimally invasive method ideal for fractures with significant soft tissue damage. It stabilizes bones without disturbing the fracture site, aiding biological healing and lowering infection risks associated with internal fixation.

Image based AI model for parasite infections in mithun

ICAR-National Research Centre on Mithun, Nagaland, has initiated an AI-based smart system using CNNs to revolutionize the identification and diagnosis of parasitic infections in Mithun and allied domestic bovines in the NEH region.

Widely used in large animals like cattle, buffaloes, and horses, ESF is particularly effective for long bone fractures (e.g. tibia, radius, metacarpus) where casts are inadequate. A newly designed bilateral fixator simplifies application and allows post-fixation adjustments. Circular ESF systems are favoured for their stability and effectiveness in short bone segments, while free-form fixation with acrylics or epoxies offers flexibility and works well for open, infected fractures in smaller animals.

Green nano-antibacterial technology to combat multi-drug-resistant bacteria in poultry: ICAR-National Meat Research Institute, Hyderabad developed a targeted delivery approach with the unique combination of encapsulated green nano silver-entrapped phytochemical molecules (cinnamaldehyde or thymol) to address MDR pathogens (*E. coli* and Non Typhoidal *Salmonella* spp.) in poultry.

Animal Disease Informatics: The National Animal Disease Referral Expert System v2 (NADRESv2) generated 5,655 risk predictions for major livestock diseases, which were communicated to the key stakeholders, including State Animal Husbandry Departments (and NADEN centers) and the Department of Animal Husbandry and Dairying, Government of India. The information was provided in the form of risk maps, monthly forewarning bulletins, and post-prediction maps to aid preparedness. The risk alerts were sent to farmers via SMS through innovative initiatives like FARMERS Empowerment through IT and the Farmer Registration and Unified Beneficiary Information System (FRUITS), a NIC web application from the Government of Karnataka. A total of 17,561,472 SMS alerts were issued to farmers in Karnataka regarding various animal diseases, viz. Anthrax, Babesiosis, Black quarter, Bluetongue, FMD, and Theileriosis. Nation-wide sampling plans for sero-surveillance and monitoring of FMD, Brucellosis and PPR were generated for each state and UT, and provided to the Department of Animal Husbandry and Dairying (DAHD), Government of India, to enhance the surveillance system. District-wise sampling plans for sero-surveillance of 15 one- health diseases were developed to assess the prevalence of these diseases across the country.

Sero-epidemiology: Screening of 57,309 serum samples from multiple animal species for major livestock diseases was carried out, with samples provided by NADEN units and State Animal Husbandry Departments. A total of 7,858 buffalo serum samples from various Indian states were tested for Brucellosis, with a positivity rate of 33.4%. Additional serodiagnostic services identified infection rates for diseases like IBR (27.3%) and Trypanosomosis (45.1%) in cattle and small ruminants. Screening for the One Health disease Leptospirosis was also performed in both humans and animals. Out of 1,798 serum, urine, and blood samples tested via MAT, 120 serum samples showed positive reactions to different Leptospira serovars.

Vaccines

Inactivated Bovine Viral Diarrhea Virus (BVDV-1) vaccine for cattle: The first indigenous inactivated whole-virus vaccine for Bovine Viral Diarrhea Virus (BVDV-1) was developed to aid in the prevention and control of BVDV infections in cattle. This vaccine provides protective immunity against BVDV-1 strains circulating in India, with immunity established by 35th day post-vaccination and lasting up to 12 months. Field studies have demonstrated a protective immune response in vaccinated cattle for up to 6 months and partial immunity against infections caused by BVDV-2 and HoBi-like pestivirus (HoBiPeV).

Evaluation of the safety, immunogenicity and efficacy of a new live-attenuated lumpy skin disease vaccine in India: The safety, immunogenicity and efficacy of a new live-attenuated LSD vaccine developed using an Indian field strain (LSDV/India/2019/Ranchi) was evaluated. The vaccine named as Lumpi-ProVacInd did not induce any local or systemic reaction in calves (n=10). At 30 days post-vaccination (pv), the vaccinated animals developed antibody- and cell-mediated immune responses, and exhibited complete protection upon virulent LSDV challenge. A minimum Neethling response (0.018% animals; 5 out of 26,940 animals) of the vaccine was observed in the field trials conducted in 26,940 animals. There was no significant reduction in the milk yield in lactating animals (n=10,108). Moreover, there was no abortion or any other reproductive disorder in the pregnant animals (n=2,889). Sero-conversion was observed in 85.18% animals in the field by day 30 pv.

Diagnostics

Monoclonal antibody-based competitive ELISA: A monoclonal antibody-based competitive enzyme-linked immunosorbent assay (cELISA) was developed for detecting antibodies against foot-and-mouth disease virus (FMDV) non-structural proteins (NSPs). The assay demonstrated a relative diagnostic sensitivity of 93.52% and specificity of 97.46% compared to the PrioCHECK FMD NS test. At a 45% PI (percent inhibition) cut-off, it achieved an overall concordance of 86.13% with the r3AB3 NSP-ELISA. This assay is anticipated to support FMD sero-surveillance and differentiation of infected from vaccinated animals (DIVA) across all FMD-susceptible species.

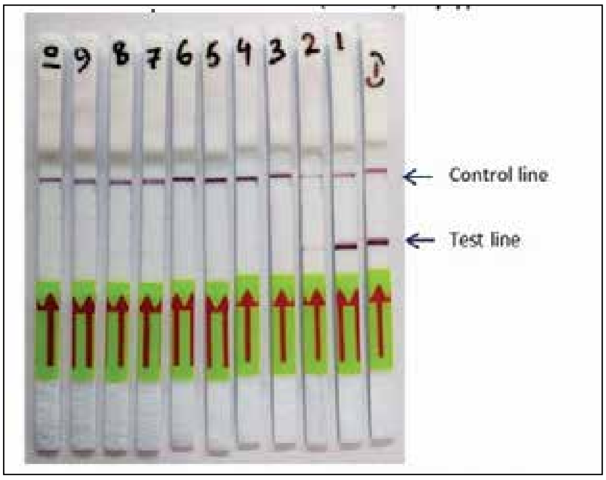
Cost-effective SARS-CoV-2 antigen capture ELISA: A safe, cost-effective, and high-throughput SARS-CoV-2 antigen capture ELISA was developed for large-scale screening, particularly in low-resource settings. The assay, validated using swab samples from humans, bovines, and dogs, demonstrated a detection limit of 195 pg/100 µL of the N protein. It exhibited a sensitivity of 67.78% and a specificity of 100%. The results correlated well with the VIRALDTECT II Multiplex RT-qPCR kit (κ values = 0.73–0.80) and the CoVeasy™ COVID-19 rapid antigen self-test (κ values = 0.89–0.93). This ELISA offers a reliable and accessible tool for SARS-CoV-2 surveillance across diverse settings, especially in low and middle-income countries.

Blocking ELISA to detect Covid-19 antibodies in animal or human population: Considering the cross-species transmissibility of SARS-CoV-2, there is a need to develop diagnostic tools capable of detecting antibodies in various animal species. These diagnostics play a crucial role in population surveillance and monitoring the infection. The antibody response against the N protein is observed relatively earlier than the S glycoprotein in convalescent sera. A panel of 16 mouse monoclonal antibodies (mAb) were produced against the purified SARS-CoV-2 N protein expressed using baculovirus system. One of the mAbs, exhibiting high reactivity with recombinant antigen and viruses, was selected for application in the antibody detection ELISA. The test successfully detected antibodies in the wild animals affected with Covid-19. The results highlighted the potential use of mAb based ELISA in the cost-effective and quick detection of antibodies across various domestic and wild animal species.

Monoclonal antibody based competitive ELISA for the detection of canine distemper virus: An indigenous monoclonal antibody (mAb)-based cELISA was developed for detecting antibodies against canine distemper virus (CDV) in both domestic dogs and wildlife with results available within 4 hour. It allows testing of non-sterile samples without requiring cell culture or virus-handling facilities. This cELISA uses the monoclonal antibody CDV-3D8, generated from an indigenous virus isolate, CDV(Dog)/Bly/Ind/2018**,** which belongs to the newly identified genetic lineage India-1/Asia-5**,** currently circulating in India. The

technology is cost-effective and serves as a substitute for the gold-standard serum neutralization test (SNT) for CDV antibody detection. Additionally, it can be used to monitor vaccinated animals immunized with exotic or other CDV strains, offering broad applicability and significant utility in disease control programmes.

Isothermal RPA-CRISPR-LFA assay for point-of-care detection of Porcine circovirus 3 (PCV3) in pigs: The isothermal recombinase polymerase amplification (RPA) coupled with CRISPR based LFA assay was developed for point-of-care detection of PCV3 nucleic acids. The CRISP/CAS based cleaved fluorescence probe in positive RPA reaction, was detected in LFA strips. In positive reaction, test line shows strong band with very light to no band in control line. The assay was validated with qPCR assay and showed comparative results. The developed assay is highly specific and detection limit is comparable to qPCR. The standardized RPA-CRISPR-LFA assay was tested for detection of PCV3 in previously collected clinical samples. The developed assay successfully detected the positive field cases. The developed assay could serve as versatile POC platform for rapid detection of PCV3 nucleic acids in pigs. PCV3 virus is associated with reproductive failure and piglet mortality in pigs which incurs huge economic losses in swine industry.



RPA-CRISPR-LFA detection of PCV3 in clinical samples

Modified colorimetric assay for rapid detection of extended-spectrum beta-lactamases (ESBL): A modified colorimetric assay was developed for the rapid and reliable detection of extended-spectrum beta-lactamase (ESBL) producers, addressing the need for timely identification critical to antimicrobial resistance (AMR) surveillance and appropriate therapeutic management. Unlike traditional methods such as combined disk or broth dilution tests, which require 18–24 hours for results, this assay delivers results faster using specific substrates and reagents to detect a wide range of ESBL variants and sub-variants. The assay is simple to implement in any standard microbiology laboratory without requiring specialized equipment or technical expertise. Operating on a colorimetric principle, it provides clear and easily interpretable visual results. It demonstrates higher sensitivity and specificity compared to the CLSI-recommended disk diffusion test. The assay effectively detects ESBL production in major isolates such as *Escherichia coli, Klebsiella pneumoniae*, and *Salmonella enterica* of animal origin. Furthermore, the colour change is stable over time, ensuring reliable result interpretation. This assay offers a cost-effective and efficient tool for advancing AMR surveillance and supporting therapeutic decision-making.

Modified ESBL colorimetric assay

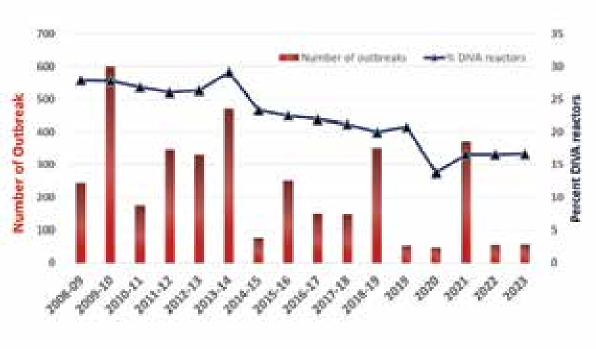
ELISA kit for LSD: For early detection and screening of LSD, LympyScreen rELISA and the Lumpysure wELISA kits were released by the ICAR-NIVEDI, Bengaluru for supporting disease control and surveillance programme.

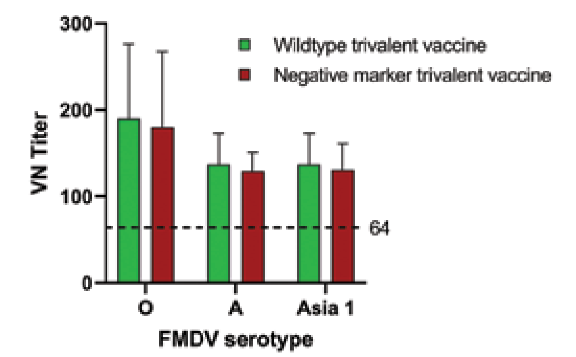
Glanders surveillance in equines: A National Action Plan on Glanders in India was launched by the Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, in 2019. A two-tier diagnostic system (ELISA and CFT) is being followed for the surveillance purposes. The State laboratories are using commercially available Glanders ELISA kit manufactured by Genomix Diagnostic Pvt. Ltd. As per guidelines, network laboratories conduct initial screening by ELISA and positive samples retested and confirmed by complement fixation test (CFT) and molecular methods. During reporting period, a total of 22,756 samples were tested and 33 were positive for Glanders.

Foot and mouth disease

Serosurveillance and seromonitoring of foot and mouth disease: A total of 49,481 serum samples were collected from various species across the country and tested using r3AB3 NSP-ELISA. The samples included cattle (31,916), buffalo (15,450), sheep (913), goat (2,014), pig (51), yak (495), and mithun (89). The overall seropositivity was 16.7% in bovine samples, consistent with the previous year's rate. A total of 99,715 serum samples were tested to assess vaccination efficacy. In pre-vaccination samples, protective titers were found in 35.3%, 31.2%, and 31.0% of animals against serotypes O, A, and Asia1, respectively. Post-vaccination samples showed protective titers of 68.9%, 64.0%, and 66.7% against serotypes O, A, and Asia1, respectively, by the end of round 3.

Evaluation of protective efficacy of negative marker trivalent FMD vaccine in cattle: Inactivated





Virus neutralizing antibody response (mean±SD) in cattle immunized with negative marker trivalent FMD vaccine in comparison to wildtype FMD vaccine, 28 days post-vaccination.

trivalent FMD vaccine against O, A and Asia1 has been used in the bi-annual vaccination programme. Traces of viral non-structural proteins (NSPs) in the current vaccines interfere in the serology-based differentiation of infected from vaccinated animals (DIVA). Reverse genetics approach-based development of negative marker vaccine constituting Indian vaccine strains of FMDV serotypes O (IND R2/75), A (IND 40/2000) and Asia 1 (IND 63/72) with deletion in portion of NSP (3A protein) of vaccine viruses, was developed. The inactivated negative marker trivalent FMD vaccine formulation was evaluated in a limited number of cattle, a natural host for FMD. Cattle immunized with negative marker vaccine demonstrated neutralizing antibody response comparable to those vaccinated with wild type vaccine, on day 28 post vaccination. Both groups exhibited similar protection efficacy against homologous live virus challenge. This vaccine would be a promising alternative to currently used vaccine, especially as India advances towards achieving a disease-free status through a combined strategy of vaccination and rigorous disease surveillance.

Capsid sequencing and vaccine matching: Capsid coding region (P1/VP1) sequences of 45 FMD viral strains were determined and analysed (28 serotype O, 16 serotype A, and 1 serotype Asia1). In serotype O, dominance of the O/ME-SA/Ind2001e and O/ME-SA/2018 lineages were found, while G-18/2019 non-deletion lineage in serotype A and Group IX in serotype Asia1 were the exclusive lineage to be detected. The vaccine strains of serotypes O and Asia1 showed good antigenic match. While serotype A isolates showed no antigenic match with the current vaccine strain A/IND/40/2000, the proposed candidate vaccine strain A/IND/27/2011 demonstrated a perfect antigenic match with recent serotype A field isolates.

Thermostable FMDV vaccine strain: A FMDV serotype Asia1 strain was selected through serial passage under heat stress and isolated by plaque assay. The selected variant demonstrated superior thermal stability compared to the parental strain under various temperature-time combinations.

RT-LAMP assay: A colorimetric RT-LAMP assay was developed for sensitive and specific detection of FMD virus circulating in India in a pan-serotypic manner. The assay demonstrated a detection limit of 1,000 copies of the FMDV viral genome, making it 10 times more sensitive than the agarose-gel-based multiplex RT-PCR assay.

TaqMan RT-qPCR assay: A duplex TaqMan probe-based one-step RT-qPCR assay was developed, simultaneously targeting the FMDV 2B NSP-coding region and 18S rRNA housekeeping gene. The assay demonstrated 100% diagnostic sensitivity and specificity, and it holds potential for routine high-throughput FMDV diagnosis.

Exotic/Emerging diseases

Lumpy skin disease: Genetic and phylogenetic analysis of the complete sequences of G protein-coupled receptor (GPCR), RNA polymerase subunit 30 (RPO30), and extra-cellular enveloped virus (EEV) genes revealed that the lumpy skin disease virus (LSDV) isolated from yaks and cattle during the 2022–2023 outbreaks belongs to the wild-type strains of the LSDV sub-cluster 1.2.1 (Eurasian lineage). This finding suggests an exotic introduction of the virus. Further, observations during the 2022 LSD outbreak in India revealed notable differences in susceptibility between indigenous and crossbred cattle. The indigenous Rathi breed demonstrated significantly lower morbidity (13.75%) and case fatality rate (27.27%) compared to crossbred cattle (87.77% morbidity and 69.51% case fatality). Peripheral blood mononuclear cells (PBMCs) from sensitized Rathi cattle showed reduced levels of miR-29a, increased CD8+ T cell counts, and elevated levels of interferon-gamma (IFN-γ) compared to those from sensitized crossbred cattle. These findings suggest that Rathi cattle elicit a stronger cell-mediated immune (CMI) response against LSDV, potentially contributing to their lower susceptibility.

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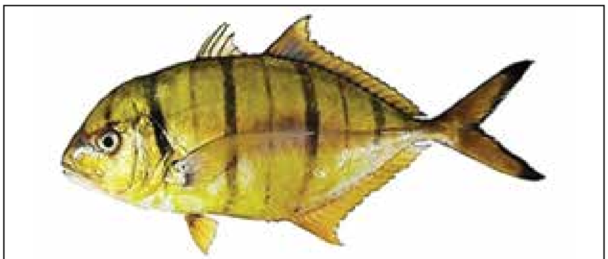
6.
Fisheries Improvement and Management

Several initiatives have been undertaken to advance aquaculture, enhance food security, and promote sustainable fish farming in India. Successfully achieved captive breeding of golden trevally (Gnathanodon speciosus), a potential species for sea farming, by raising broodstock in open sea cages for 3-4 years. The fish naturally spawned in Recirculating Aquaculture System (RAS) and larvae after 51 days, metamorphized into juveniles resulting in a 14.7% survival rate. Similarly, captive breeding of the dwarf chameleon fish (Badis blosyrus), an ornamental species from Northeast India, was successfully achived, with spawning observed in June and fry becoming free-swimming after 6-8 days at optimal water conditions. A breeding package for the peacock eel (Macrognathus aral) was also developed. Induced breeding with hormonal treatment, yielded 3,500 eggs with 45% fertilization and 20% hatching rates. Additionally, a multi-location farming trial of CIFA-GI Scampi® in Assam under the Pradhan Mantri Matsya Sampada Yojana showed promising results. Also developed and validated a GnRH injectable formulation for induced breeding of fishers. It was tested successfully in Indian major carps and other species, and was observed to enhance spawning efficiency across diverse fish species.

ICAR-CIFRI's National Ranching Programme has successfully restored native fish species like Indian Major Carps (IMC) and Mahseer in the Ganga River by releasing 49.1 lakh fingerlings across States of West Bengal, Uttar Pradesh, Bihar, Jharkhand, and Uttarakhand. This led to doubling of fish landings in the Buxar stretch (Bihar) between 2017-18 and 2023-24. In this programme 31,476 hilsa fish seeds were also released upstream of the Farakka barrage. In addition, 102 awareness programmes were conducted to promote sustainable fishing practices, reaching over 7,500 people. Developed feeds CIFE-GlowX, for enhancing growth and coloration of ornamental fishes, and Cadalmin™ Silvergrow, for better growth of silver pompano. Furthermore, ICAR-CIFE and ICAR-IARI introduced CIFE-SPOT, a rapid CRISPR-based diagnostic tool for detecting White Spot Syndrome Virus (WSSV) in shrimp, aiding proactive disease management in aquaculture.

Captive breeding and rearing of fishes: The golden trevally (*Gnathanodon speciosus*), a potential fish species for sea farming, has significant market demand for both consumption and ornamental purposes. ICAR-CMFRI successfully achieved seed production of this species in captivity. The broodstock fish were raised in open sea cages for 3-4 years until they reached maturity (3.5-4.5 kg). These fish spawned naturally in land-based Recirculating Aquaculture System (RAS) at Visakhapatnam. Following hatching, the larvae were reared on live feeds, and after 51 days they metamorphized into juveniles. The survival rate from larvae to juveniles was recorded at 14.7%, marking a successful step in the development of golden trevally farming.



Golden trevally (*Gnathanodon speciosus*)

Broodstock and life stages of golden trevally

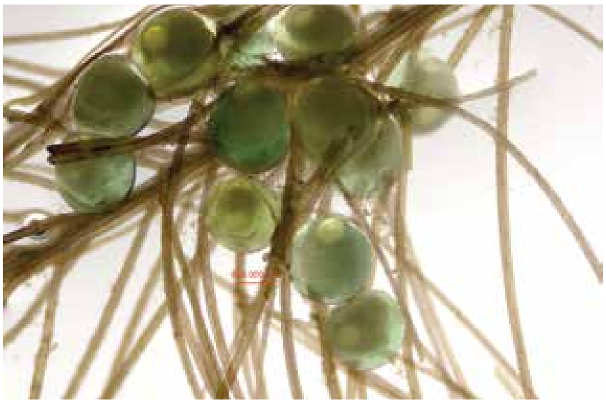
Captive breeding of dwarf chameleon (*Badis blosyrus)*, an indigenous ornamental fish of North-East region of India, was successfully achieved. Adult fish were collected from Deepor beel and nearby streams in Kamrup (Metropolitan) district of Assam during January and were acclimatized to captive conditions. Courtship behavior was observed during March-April. The mature fish, with respective total length and weight of 6.8 cm, 3.8 g for female and 8.0 cm, 3.5 g for male were transferred to rectangular FRP tank with rounded corners. The tank was furnished with pebbles, submerged plants, and earthen pots to provide hideouts. The fish were fed *ad libitum* with wet feeds (chicken liver and ant eggs). Spawning was observed during June and the male fish guarded eggs inside the pot. The eggs hatched in 2-3 days and larvae became free swimming after 6-8 days. The water quality parameters found optimum for breeding trial were temperature 20-28°C, pH 7.0, dissolve oxygen 6-8 mg/l, alkalinity 100-184 mg/l, and ammonia (NH_3) levels between 0-0.0012 mg/l .

Breeding pair of *Badis blosyrus* in FRP tank

Gravid female, mature male and 45 days old fry (*top to bottom*) of *Badis blosyrus*

Developed package of practices for captive seed production of peacock eel (*Macrognathus aral*), an important food fish of North-East India, Bihar and Jharkhand. The technology comprised-captive broodstock development, induced breeding and larval rearing. Under captive conditions, the fish attained

Peacock eel broodstock



Peacock eel fertilized eggs

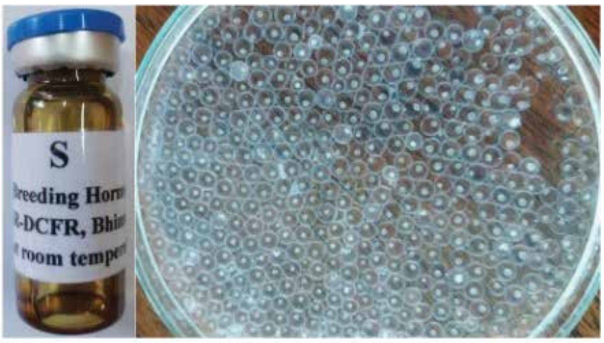
Peacock eel seven days old larvae

Peacock eel forty-five days old fry

SUCCESS STORY

Multi-location farming of 'CIFA GI-Scampi®' in Assam

Multi-location farming of 'CIFA-GI Scampi®' in carp-scampi polyculture system was conducted in farmers ponds at Kamrup district of Assam during 2023-24 under the Pradhan Mantri Matsya Sampada Yojana (PMMSY), a Central Sector Scheme. The stocking density of CIFA GI-Scampi® post larvae (0.05 g) was maintained at 10,000 per ha, along with *Catla catla* (150.00 ± 8.27 g) and *Labeo rohita* (100.00 ± 9.87 g) stocked at 6,000 per ha in 1:4 ratio. Stocking was undertaken during mid-September 2023 and harvested on 19 March 2024, from the two farmers ponds, Akadi village, Hajo Block; one pond each in Tarani village, Rangia Block and Rajapukhuri village, Rampur Block. After 185 days of culture, the final average body weight of CIFA GI-Scampi® ranged from 58 to 80g, while for *C. catla*, was 768-909 g and *L. rohita*, ranged from 546 to 655 g. This trial marked the first use of 'CIFA-GI Scampi®' in the NEH states.



GnRH analog Fertilized eggs from Jayanti rohu

Ovaqua: GnRH formulation

sexual maturity at body weight of 18-25 g in mid-June. In the first week of July, mature fish with a sex ratio of 2:1 (M:F) were segregated and administered with inducing hormone, a combination of LHRHa and domperidone. Spawning occurred offer 18 hours. The fertilized eggs were greenish, spherical and adhesive in nature. Roots of pistia plant were used as substrate for eggs to adhere. Fertilization and hatching rates were recorded at 45% and 20%, respectively. The larvae hatched after an incubation period of 18 h at a 28°C water temperature. The newly hatched yolk-sac larvae measured 1.65 and 1.85 mm. For nursery rearing, the larvae were transferred to outdoor tanks provided with *Pistia* as hideouts. The yolk-sac was utilized within five days post-hatching (dph), after which exogenous feeding was initiated with *Artemia* nauplii for 30 days followed by weaning to micro-particulate diet.

Ovaqua, GnRH formulation for induced breeding in fish: ICAR-DCFR has developed and validated a potent GnRH injectable formulation for induced breeding of fishes. The formulation was tested in field conditions at different locations. The GnRH formulation could successfully induce spawning in Indian Major Carps in Uttarakhand and Gujarat as well as in Bangana dero in Manipur. The developed hormonal formulation was less viscous, hence it was easy to inject, and was found to be highly efficient in inducing spawning different fish species.

Fish ranching in River Ganga: ICAR-CIFRI implemented the 'National Ranching Programme' and organized, conducting 25 ranching activities across States during the year 2023-24 to restore the native fishes of the Ganga river namely, Indian Major Carps (IMC) and Mahseer. About 49.1 lakh fingerlings of these species produced through induced breeding of Gangetic brooders were released in the river. The fish ranching efforts were conducted across West Bengal (51%), Uttar Pradesh (33%), Bihar (14%), Jharkhand (2%) and Uttarakhand (0.3%). As a result of ranching, there was an increase in IMC landings from the Buxar (Bihar) stretch of the river, reaching 1.84 tonnes during the 2023-24 period, compared to 0.97 tonnes in 2017-18. Additionally, an increase of 14.6 tonnes of IMC was recorded from the Prayagraj (Uttar Pradesh) stretch of the river in 2022-23, compared to 11.4 tonnes in 2020-21. Further, 31,476 seeds of hilsa fish were released upstream of the Farakka barrage to help replenish the population of this species.

Under the National Mission for Clean Ganga (NMCG), ICAR-CIFRI, organized 102 awareness activities across Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. These programmes reached approximately 7,530 indivuals, including fishermen, fisherwomen, students, local communities, entrepreneurs, raising awareness about the importance of sustainable fishery practices.

Fish feed formulations

CIFE-GlowX: ICAR-CIFE developed a nutritionally balanced feed aimed at enhancing the coloration, growth, and survival of freshwater ornamental fish species such as goldfish, koi carp, barbs, guppy, molly, tetra, swordtail, angel fish, and others. This feed contains 32% crude protein, 6% lipids, 8% fiber, and provides 3.9 kcal/g of gross energy. The feed was tested two locations at Bhandup (Mumbai) in goldfish (*Carassius auratus*) and at Ambernath (Mumbai) in albino Buenos tetra (*Hyphessobrycon anisitsi*). The performance of CIFE-GlowX recorded much better colouration with 46% increase in goldfish and 18% increase in albino Buenos tetra. Growth rates also improved with 25% increase observed for both the species.

Cadalmin™ Silvergrow: Cadalmin™ Silvergrow is a novel grow-out feed specifically designed for silver pompano. This feed is formulated to promote growth

Women fisher folks ranching fish in Ganga River at Balagarh, West Bengal

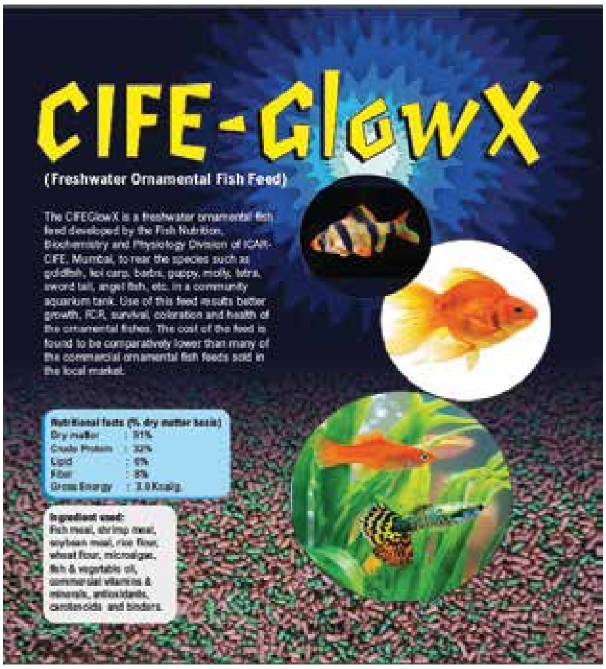
Fish ranching in Ganga River at Rishikesh, Uttarakhand by Shradhey Acharya Bal Krishna Ji, VC, Patanjali University and Ayurvedacharya, Patanjali Yogpeeth Haridwar

Fish ranching in Ganga River at Sahibganj, Jharkhand by Hon'ble Union Minister of state, Ministry of Ports, Shipping and Waterways Shri Shantanu Thakur

Awareness campaign organized during fish ranching programme

rates and improve feed conversion efficiency in silver pompano, Cadalmin™ Silvergrow is rich in essential nutrients, containing 38% protein and 8% fat. It includes a high-quality blend of marine proteins sourced from fish, shrimp, and clams, along with soy flour, wheat flour, fish oil, vitamins, minerals, antioxidants, and antifungal agents. This balanced composition ensures optimal growth and health for silver pompano making it ideal for use in both sea cage and pond culture environment. The feed has been commercialized.

CIFE-SPOT: ICAR-CIFE and ICAR-IARI have jointly developed CIFE-SPOT, a CRISPR-based, highly sensitive isothermal lateral flow diagnostic test for



Cadalmin™ Silvergrow

detecting White Spot Syndrome Virus (WSSV) from crude infected tissue extracts. The isothermal nature of the assay enables rapid diagnostics within 1-2 h, eliminating need for complex temperature control equipment. This innovative system holds immense potential for aquaculture disease management. It can be used for early infection screening in broodstock, fry, and shrimp larvae, facilitating preventive measures. Additionally, the platform can detect viruses in water samples, enabling proactive monitoring and outbreak prevention. It can also identify asymptomatic carriers and latent infections in shrimp, aiding in disease control efforts.

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7.
Genetic Resources

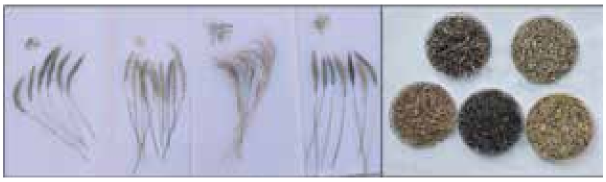
ICAR made significant advancements in agrobiodiversity management through its five national bureaux. For plant genetic resources (PGR), the ICAR-NBPGR conducted 20 germplasm exploration missions across India, collecting 1,000 accessions, including cultivated and wild species. The National Herbarium of Cultivated Plants processed 198 specimens, adding 24 new taxa. The National Genebank received 3,198 new seed accessions, increasing the total to 470,513. The In-Vitro Genebank added 39 accessions, and 225 accessions were cryopreserved, bringing the total to 13,047. Additionally, 40,094 accessions were imported, and 756 wheat samples were exported to Namibia. Characterization of 20,192 accessions focused on stress resistance, with core sets developed for sesame, barley, and barnyard millet. Plant quarantine processed 134,067 imported samples. DNA fingerprinting of 61 varietal samples and GMO testing of 23 consignments were completed. Genome sequencing identified quantitative trait nucleotides (QTNs) for yield and drought resistance. The registration of 144 new germplasm entries increased the National Genebank total to 2,284, supporting trait-based breeding. In horticulture genetic resources (HGR), notable additions included 92 in-vitro potato accessions from international sources, as well as several species of Piper collected from the North-eastern regions of India. In animal genetic resources (ANGR), ICAR-NBAGR registered seven new indigenous breeds, bringing the total to 219. The phenotypic characterization of the Rohilkhandi cattle breed revealed a daily milk yield of 5.21 kg. Whole genome sequencing was completed for the Arunachali yak and Mithun populations. ICAR also developed genomic chips for indigenous cattle and buffaloes. For ex-situ conservation, the ICAR-NBAGR cryopreserved semen and somatic cells from 29 out of 38 at-risk indigenous breeds. New fish and shellfish species were discovered from Indian waters and genetic characterization of aquaculture species was conducted, including whole genome sequencing of Indian major carp by ICAR-NBFGR. Two online databases, Crustacea RIS and HilsaTranscripSSRDB, were developed to support research in crustaceans and Hilsa shad. The Culture Collection at ICAR-NBAIM was enhanced with 604 new strain, making a total of 8,500 microbial accessions. It supplied 119 cultures to institutions and accessioned 21 cultures for safe deposition. DNA fingerprinting of 450 samples of microbial cultures to be registered as biopesticides were carried out at ICAR-NBAIM. Insect DNA barcoding and new insect species discoveries by ICAR-NBAIR has enhanced biodiversity understanding and pest management.

Plant Genetic Resources (PGR)

Germplasm exploration: A total of 20 explorations were conducted, collecting 1,000 accessions (611 cultivated and 389 wild) from parts of Assam, Arunachal Pradesh, Chhattisgarh, Haryana, Jammu and Kashmir, Karnataka, Leh-Ladakh, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttarakhand, and Uttar Pradesh. The collection includes landraces, crop wild relatives (CWR) of cereals, pulses, vegetables, fruits, and medicinal plants.

A total of 198 herbarium specimens were processed and added to the National Herbarium of Cultivated Plants (NHCP), ICAR-NBPGR, New Delhi, bringing the total to 26,394 specimens. The collection include 24 new taxa. Additionally, 2,609 virtual herbarium specimens were added to the NHCP database, increasing the total to 3,248.

Germplasm conservation: A total of 3,198 accessions of orthodox seed species were added to the



Variability in *Elymus* spp. a wild relative of wheat, from remote areas of Leh and Ladakh

Wild relatives of bitter gourd, *Momordica subangulata* subsp. *subangulata* from Phek, Nagaland and *M. charantia* var. *muricata* from Seoni, Madhya Pradesh

National Genebank for long-term storage, bringing the base collection to 4,70,513 accessions as of September 30, 2024. Additionally, 39 accessions of fruits, tubers, bulbs, and medicinal plants were incorporated into the *in-vitro* Genebank, increasing the collection to 2,041 accessions, comprising approximately 43,000 *in vitro* cultures from 69 genera and 171 species. Furthermore, 225 accessions of seeds and pollen of various crop species were successfully cryopreserved, raising the total to 13,047 accessions across 981 species as of 30th September 2024. Additionally 2,194 genomic resources were cryopreserved.

Germplasm exchange: A total of 40,094 accessions were imported from 36 countries. Additionally, 34,449 entries (1,62,715 samples) of *germplasm under development*' were imported in trials/nurseries from CG Centres. Additionally, 756 wheat samples (378 advanced cultivars each to Mexico and Bangladesh) were exported to Namibia under collaborative research projects.

Germplasm characterization/evaluation: A total of 20,192 accessions of various agri-horticultural crops, including mungbean (398), linseed (431), linseed-derived lines (1,700), linseed wild species (22), grasspea and crop wild relatives (CWR) (4,000), wild lathyrus (271), wheat (6,644), triticale (1,182), proso millet (1,451), barnyard millet (1,888), soybean (250), maize (100), Indian mustard (400), and sesame (1,455), were characterized and evaluated for various traits. In terms of biotic stress resistance, 3,864 accessions were evaluated for resistance to ChiLCD, mites, and thrips in chilli (180); root-knot nematode (RKN) in chickpea (1,500); and MLB/BLB resistance in maize (2,184). For abiotic stress resistance, 3,924 accessions were evaluated for different crops, including linseed (299) for heat and drought tolerance, barley (678) for combined heat and drought stress, chickpea (1,500) for drought tolerance, durum wheat (311) for combined drought and heat stress, bread wheat (800) for drought, and dicoccum wheat (25) for terminal heat tolerance. Additionally, 2,000 accessions from red rice, wheat, persimmon, *Ziziphus, Dioscorea deltoidei*, maize, sesame, lawsonia, wild *Vigna*, pulses, and minor millets were evaluated for various biochemical parameters. Sesame germplasm core set (763 accessions) and composite core set (1,455 accessions) were developed. In linseed, reference sets were established for bud fly resistance (155 accessions), drought tolerance (200 accessions) and *Alternaria* blight resistance (256 accessions), with genotype IC0591124

Key introductions of trait-specific plant germplasm

National Identity	Crop	Source country and ID	Trait(s)
EC1221521	Wheat cv. Warhorse	USA (CV 1096, PI 670157)	Improved resistance to wheat stem sawfly, solid stem, short stature, and high yield
EC1221522	Wheat cv. Colter	USA (CV-1099, PI 670156)	High-yielding variety with medium to high grain protein content, improved grain volume weight, and stem rust resistance
EC1218863-1219084; EC1203272-1203632	Soybean	USA	Elite lines and promising varieties for specific traits
EC1223139-1223140	Tomato	USA	Bacterial wilt-resistant lines
EC1187582-1187666	Castor	USDA, USA	Promising lines
EC1194984-1195006	Muskmelon	USA	Powdery mildew and fusarium wilt differentials
EC1190482-1190498	Cumin	USA	Fragrant lines
EC1194596	Cotton var Himalayan	Nepal	Strong fibre and good length

Germplasm characterization and evaluation. (A) Development of core set in Sesame; (B) Reference set for *Alternaria* blight in linseed; (c) Resistant accession IC0591124 in linseed; (D & E) Mega characterization of barnyard millet; (F) Field day organized at ICAR-NBPGR, Issapur Farm on Indian barnyard millet confirmed as resistant. A barley mini-core collection comprising 107 accessions was developed and evaluated for salinity tolerance. A mega characterization of 1,888 accessions of barnyard millet was conducted at two locations (NBPGR, Issapur Farm, and Hyderabad), revealing significant agro-morphological diversity, and a core set was prepared based on this diversity.

Plant quarantine: A total of 1,34,067 imported samples were processed for quarantine clearance, out of which, 1,033 samples were infested/infected with different pest. Of these, five samples were rejected due to fungal pathogens of quarantine importance. Important interceptions included fungi (*Phoma exigua, Claviceps purpurea, Cephalosporium maydis, Xanthomonas campestris* pv. *campestris*) and insects (*Bruchus dentipus*, *Sitophyllus granarius*). Nematodes were intercepted in 310 samples and viruses in six samples, which is not reported from India. Seven noxious weeds not reported from India were found (*Avena sterilis, Bromus secalinus, Centaurea melitensis, Echinochloa crus-pavonis, Lolium rigidum, Phalaris paradoxa, Polygonium lapathifolium*).

In the case of paddy, 1,345 samples underwent mandatory hot water treatment. A total of 225 vegetative propagules received prophylactic pesticidal dip treatment. Additionally, 13,758 seed samples were fumigated, and 237 rice samples infected with nematodes were salvaged through hot water treatment. Rooted samples of pear and apple infected with nematodes (73) were salvaged using root-dip treatment. Prophylactic treatment was also applied to 1,241 imported samples of *Capsicum* spp. and *Lycopersicum* spp. A total of 44 post-entry quarantine inspections were conducted for imported consignments at the indentor's site. Furthermore, 830 samples were processed for export, resulting in the issuance of five Phytosanitary Certificates. Additionally, 13,348 indigenous samples were processed for pest-free conservation.

DNA Fingerprinting and Genome Sequencing

During the period under report, 61 varietal samples of 22 crops were DNA profiled using simple sequence repeat (SSR) markers. Genetically Modified Organism (GMO) testing services were provided for 23 consignments comprising 53 samples of five crops (banana, papaya, maize, sunflower, and yellow mustard). Molecular testing of 73 samples of imported transgenic seeds as well as 52 samples of Bt cotton hybrids and parental lines was done.

In whole genome sequencing, a *de novo* chromosome-scale assembly of Kasuri methi was completed, spanning 798 Mb with 282 scaffolds. In millets, a draft whole genome sequence of the browntop millet was *de novo* assembled spanning 699 Mb covering 98% of the estimated genome size of 710 Mb and identified 60,759 genes. Further, a chromosome-scale reference genome assembly (787.2 Mb) was generated for the wild rice species *Oryza meyeriana* var. *indandamanica*. The complete chloroplast genomes of four wild Indian *Musa* taxa (size ranging from 169,485–169,861 bp) were sequenced. In sesame, genotyping of 5,856 sesame accessions were completed using the ddRAD-seq approach. In rice, through genome-wide association studies (GWAS), utilizing 35,286 high-quality single-nucleotide polymorphisms (SNPs) on panel of 483 rice genotypes sourced from a northeast core set and landraces from various regions in India, a total 40 quantitative trait nucleotides (QTNs) were identified. For yield traits in rice, GWAS using on association mapping panel of 198 accessions with 5,53,229 SNPs, a total of 73 QTNs were identified. In cowpea, 10 stable QTNs were identified for 100 seed-weight in a panel of 419 accessions. In rice bean, transcriptome-wide association analysis enabled identification of key genomic regions governing important agronomical traits was done. In moth bean, a total of four genomic regions having significant effect on the seed size were identified.

Plant Germplasm Registration

A total of 144 special trait germplasm/donors of 55 species were registered taking the tally of total trait specific germplasm registered in the National Genebank to 2,284 for use in the trait based breeding by the scientists working in National Agricultural Research System.

Summary of trait-specific germplasm registered during October, 2023 to September 2024 with current status of donors registered by Plant Germplasm Registration Committee

Crop group	No. of germplasm entries registered	Present status
Cereals and Pesudocereals	55	817
Millets	03	158
Fibre and Forages	00	130
Grain Legumes	12	226
Vegetables	05	142
Oilseeds	19	276
Commercial Crop	05	124
M&AP, Spices and Masticatory	08	140
Fruits and Nuts	16	85
Tubers	05	61
Ornamentals	15	107
Narcotic/Beverages	00	09
Agro-forestry	01	09
Grand Total	144	2,284

PGR Policy at Global Level

ICAR-NBPGR provided leadership in the area of global negotiations on the enhancement of the multilateral system of access and benefit sharing under International Treaty on Plant Genetic Resources for Food and Agriculture. During the reporting period, scientist from the Bureau functioned as the Co-Chair of the Working Group and managed two meetings (15-18 April and 15-21 September 2024) at FAO, Rome. Scientist from the Bureau also participated as India's nominee in the 'Southern Negotiators Informal Science-Policy Dialogue on DSI' held at CIAT, Cali, Colombia (8-9 July 2024).

Trait-specific germplasm registered at ICAR-NBPGR

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Rice/*Oryza sativa*	IC650728	23068	Multiple tolerance to sheath blight, sheath rot, rice tungro disease (RTD), leaf blast and neck blast diseases. Drought tolerance-high yield under reproductive stage drought stress
Rice/*O. sativa*	IC650729	23069	Strong culm
Rice/*O. sativa*	IC650730	23070	Resistance to gall midge, bacterial blight, and blast
Rice/*O. sativa*	IC650767	23071	Reproductive stage drought tolerance. Resistance to blast and bacterial blight
Rice/*O. sativa*	IC635486	23072	Salt tolerance (EC-5 to 11.95 dS/m)
Rice/*O. sativa*	IC650731	23073	Tolerance to reproductive stage drought stress and submergence. Resistance to blast disease
Rice/*O. sativa*	IC650732	23074	High grain Zn content (28.22 ppm) in polished rice grain. High protein content (8.08%) in polished rice grain
Rice/*O. sativa*	IC650734	23075	High grain Zn content (24.32 ppm) in polished rice grain
Rice/*O. sativa*	IC650733	23076	High and stable grain yield under N-Low, N-50 and N-100 fertilizer input. High nitrogen-use efficiency under N-Low and N-50 input
Rice/*O. sativa*	IC650735	23077	High and stable grain yield under N-Low, N-50 and N-100 fertilizer input. High nitrogen-use efficiency under N-Low and N-50 input. High nutrient (NPK) uptake and high grain yield under native sodic soil conditions (without gypsum amendment; pH 8.5 – 10.0)
Wheat/*Triticum durum*	IC642306	23078	High grain zinc content (47.1 ppm). High grain protein content (13.9%)
Wheat/*T. aestivum*	IC648497	23079	Drought tolerance: drought sensitivity index (DSI) of 0.682. Heat tolerance: heat sensitivity index of (0.69)
Wheat/*T. aestivum*	IC648496	23080	High 1,000 kernel weight 49 g
Wheat/*T. aestivum*	IC648495	23081	Resistance to spot blotch disease. Terminal heat tolerance
Wheat/*T. aestivum*	IC650736	23082	One major gene each for stem rust (*Sr36*), leaf rust (*Lr45*) and powdery mildew (*Pm6*) resistance. Adult plant rust resistance genes (*Sr2/Lr27/Sr30*). Resistance to the prevailing stem rust, leaf rust and powdery mildew pathotypes of India
Wheat/*T. aestivum*	IC650737	23083	One major gene each for stem rust (*Sr36*), leaf rust (*Lr45*) and powdery mildew (*Pm6*) resistance. Adult plant rust resistance genes (*Sr2/Lr27/Sr30*). Resistance to the prevailing stem rust, leaf rust and powdery mildew pathotypes of India
Barley/*Hordeum vulgare*	IC650738	23084	High protein (14.6%) and ß-glucan (6%)
Barley/*H. vulgare*	IC650739	23085	High ß-glucan (6.1%)
Barley/*H. vulgare*	IC650740	23086	Low grain ß-glucan content (3.7% dwb)
Barley/*H. vulgare*	IC650741	23087	Early heading (53 days). Early maturity (113 days)
Barley/*H. vulgare*	IC650742	23088	Drought tolerance at seedling and adult plant stage
Pearl millet/*Pennisetum glaucum*	IC650743	23089	High Fe content (95 ppm). High Zn content (53 ppm)
Pearl millet/*P. glaucum*	IC650744	23090	Resistance to downy mildew. High grain iron content (81 ppm), zinc content (49.5 ppm)
Black Gram/*Vigna mungo*	IC650745	23091	High seed iron content (162 mg/kg)
Black Gram/*Vigna mungo*	IC650746	23092	High seed zinc content (54 mg/kg)
Lentil/*Lens culinaris*	IC650748	23093	Seed-coat colour anomalies due to altered anthocyanin pathway
Lentil/*L. culinaris*	IC650747	23094	Early flowering (30-40 days) and early maturity (80-92 days)
Lentil/*L. culinaris*	IC643972	23095	High salt tolerance (ECe 5.8-6.7dS/m)
Mung Bean/*Vigna radiata*	IC650749	23096	Resistance to MYMIV infection under North Indian conditions
Mung Bean/*V. radiata*	IC650750	23097	High salt tolerance (RSC iw:4 me/l; ECiw: 5 dS/m, pH-8.8)
Chilli/*Capsicum annuum*	IC650751	23098	Resistance to Chilli Veinal Mottle Virus (ChiVMV) disease. Single gene inheritance pattern of ChiVMV
Onion/*Allium cepa*	IC650752	23099	High salinity tolerance (EC iw 7dS/ m)
Castor/*Ricinus communis*	IC650753	23100	Wilt resistance. Male monoecious line
Soybean/*Glycine max*	IC650754	23101	Resistance to multiple diseases (YMD, charcoal rot, Rhizactonia aerial blight). Moderate resistance to Asian soybean rust. Possesses alleles from *Glycine soja*: an ancestor of cultivated soybean (*Glycine max)*
Cardamom/*Elettaria cardamomum*	IC584058	23102	Compact flowering. Bold capsules (80% of capsules > 7 mm). Relative tolerance to moisture stress
Apple/*Malus* × *domestica*	IC647748	23103	Solid fruit peel colour (Greyed purple group -187-B). Early fruit peel colour (Two weeks earlier). Early maturity (Two weeks earlier)
Apple/*Malus* × *domestica*	IC647749	23104	Solid fruit peel colour (Red group-46-A). Early fruit peel colour (15-20 days earlier). Early maturity (Two weeks earlier)
Apple/*Malus* × *domestica*	IC647750	23105	Unique fruit peel colour (Red group-39-A). Early fruit peel colour (Two weeks earlier) Early maturity (Two weeks earlier)
Apple/*Malus* × *domestica*	IC647751	23106	Solid fruit peel colour (reyed purple group - 187-A). Early fruit peel colour (three weeks earlier). Early maturity (two weeks earlier)

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Avocado/*Persea americana*	IC644473	23107	Arka Coorg Ravi with high pulp recovery (80%). High fruit weight (450-600 g) and B type flowering
Sapota/ *Manilkara zapota*	IC642151	23108	CHES-Sapota-1 with extra-large fruit (6.7 cm × 6.6 cm). High fruit weight (158.8 g) and yield (42 kg/plant)
Pan Masala/ *Clausena heptaphylla*	IC650755	23109	High leaf essential oil (more than 1.22%). It has high anethole (>90%)
Shrubby Basil/*Ocimum gratissimum*	IC646863	23110	Leaf shape is broadly ovate. Rich in eugenol (75.45%) content
Marigold/*Tagetes erecta*	IC630499	23111	Resistance to bacterial wilt
Marigold/*T. erecta*	IC630500	23112	Resistance to bacterial wilt
Elephant Ears/*Caladium* sp.	IC650756	23113	Olive green leaf colour. Pink leaf spot. Red midrib
Elephant Ears/*Caladium* sp.	IC650757	23114	Green colour leaf. Red midrib colour. Pink and white leaf spots
Elephant Ears/*Caladium* sp.	IC650758	23115	Leaf colour green. Midrib colour green. Three leaf spot pink/red/white
Elephant Ears/*Caladium* sp.	IC650759	23116	Green/white contrast leaf colour. White midrib colour. White leaf spot
Elephant Ears/*Caladium* sp.	IC650760	23117	Leaf colour pink with green margin. Midrib dark pink. Leaf spot absent
Sugarcane/*Saccharum officinarum*	IC650761	23118	Resistance to whip smut under artificial inoculation
Sugarcane/*S. officinarum*	IC650762	23119	Resistance to whip smut under artificial condition
Potato/*Solanum tuberosum*	IC650763	23120	Cultivated clone (*Solanum tuberosum*; 2n=4x; 48). High vitamin C content (77.7 mg/100g FTW)
Rice/*Oryza sativa*	IC646727	23121	High total anthocyanin (116.76 mg/100g), total gammaoryzanols (86.26 mg/100g), total phenolic content (788.18 mg/100g), total flavonoid content (221.27 mg/100g), ABTS activity germplasm (3163.94.AAE/g), Low phytic acid content (0.16 g/100g)
Maize/*Zea mays*	IC644600	23122	Ligule less. Early maturing
Maize/*Zea mays*	IC644601	23123	Ligule less. Extra early maturing
Fenugreek/*Trigonellaf oenum-graecum*	IC624520	23124	Extra early maturing (93 days)
Rice/*Oryza sativa*	IC651966	24001	Wide Compatible Restorer
Rice/*Oryza sativa*	IC651967	24002	Wide Compatible Restorer
Rice/*Oryza sativa* × *O. nivara*	IC651968	24003	Wild introgression line with high resistance to BLB (Average disease score=4.7 in disease screening nursery). Four consistent BB QTLs: qBB15-4-1, qBB15-5-1, qBB15-5-3 and qBB15-6-1 *O. nivara* alleles for *Xa4* gene
Wheat/T. aestivum subsp. *aestivum*	IC651969	24004	Drought and heat stress tolerance (DSI=0.81) with lower yield reduction (25.5%) under drought stress condition (HSI=0.77) with lower yield reduction (20.1%) under heat stress condition
Wheat/T. aestivum subsp. *aestivum*	IC651970	24005	Drought tolerance (DSI=0.66) with lower yield reduction (20.8%) under drought
Wheat/T. aestivum subsp. *aestivum*	IC651971	24006	Drought stress tolerance (DSI=0.40)
Wheat/T. aestivum subsp. *aestivum*	IC651972	24007	Drought and heat stress tolerance (HSI= 0.78; DSI=0.89). Resistant to yellow rust of wheat (ACI=1.2)
Wheat/*T. aestivum*	IC651973	24008	High heat stress tolerance (HSI: 0.76) with lower grain yield reduction (20.0%) under heat stress
Wheat/T. durum	IC29040	24009	Leaf rust resistance (HS= 0; ACI=0)
Wheat/*T. aestivum*	IC651974	24010	Yellow (Stripe) rust resistance (ACI=4.3; HS=10MS)
Wheat/*T. aestivum*	IC651975	24011	Resistant to stem rust (HS=-10MR and ACI 0.7). Resistant to leaf rust (HS=10R and ACI 0.3)
Wheat/*T. aestivum*	IC651976	24012	Resistant to yellow (stripe) rust (HS= 5S; ACI 0.6). Resistant to leaf rust (HS=5MR and ACI 0.3)
Wheat/T. dicoccum	IC535133	24013	Resistant to leaf rust
Wheat/T. dicoccum	IC138898	24014	Resistant to leaf rust
Wheat/*T. aestivum*	IC651977	24015	Low phenol colour score of 3.9 and 4.1 in NWPZ and NEPZ respectively
Wheat/*T. aestivum*	EC182958	24016	High grain protein content (17.16%)
Wheat/*T. sphaerococcum*	IC634028	24017	High grain protein content (15.72%)
Wheat/*T. aestivum*	IC539313	24018	High 1,000 grain weight (55.03 g). Higher grain length (7.15 mm)
Barley/*H. vulgare*	IC651978	24019	Higher grain beta glucan content (8.0% dwb). Bold grain percentage (90.7%). High protein content (16.1% dwb).
Barley/*H. vulgare* ssp. *nudum*	IC651979	24020	Salinity tolerance (at 200 mM NaCl)
Wild barley/ *H. spontaneum*	IC651980	24021	Salinity tolerance (at 200 mM NaCl)

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Sorghum/*Sorghum bicolor*	IC651981	24022	Tolerance to stem borer (9.7% dead hearts at 45 DAE). Tolerance to shootfly (34.8% dead hearts at 28 DAE)
Lentil/*Lens culinaris*	IC643973	24023	Heat tolerance by better yield in heat screening nursery. Higher seedling survivability under controlled heat stress conditions
Cowpea/*Vigna unguiculata*	IC625644	24024	Photo-thermo insensitive under hot arid climate (10-46°C)
Cowpea/*V. unguiculata*	IC628910	24025	Photo-thermo insensitive under hot arid climate (10-46°C)
Pea/*Pisum sativum*	IC647370	24026	*Acacia* type leaf pattern
Ridge Gourd/ *Luffa acutangula*	IC648075	24027	Moderately resistant to downy mildew (Mean Percent Disease index= 23.46). Fruit is medium long, green
Indian Mustard/*Brassica juncea*	IC651982	24028	White rust resistant (2.2%). Single low erucic acid (0.2% in oil)
Indian Mustard/*Brassica juncea*	IC651983	24029	White rust resistant (3.43%)
Groundnut/*Arachis hypogaea*	IC651984	24030	Fresh seed dormancy (> 3 weeks)
Groundnut/*A. hypogaea*	IC651985	24031	Fresh seed dormancy (> 3 weeks)
Soybean/*Glycine max*	IC651986	24032	Very early maturing (71 days)
Soybean/*Glycine max*	IC651988	24033	Higher seed viability (98%, 88%, 80%). High germination % in ambient storage (61% germination in fresh, 1, 2 and 3 years of storage). Bold seeded, determinate, erect plant type. High 100-seed weight (9.41 g)
Soybean/*Glycine max*	IC651987	24034	Kunitz Trypsin Inhibitor (KTI) free. Black seed coat
Linseed/*Linum usitatissimum*	IC651989	24035	Resistance to linseed bud fly infestation in white flowered genetic background (7.33% mean bud fly infestation)
Linseed/*L. usitatissimum*	IC651990	24036	Resistance to linseed bud fly infestation in violet flowered genetic background (7.36% mean bud fly infestation)
Linseed/*L. grandiflorum*	IC651991	24037	Resistance to linseed bud fly infestation (<5% bud fly damage)
Yellow Flax/*L. bienne*	IC651992	24038	High resistance to bud fly infestation (<5% bud fly damage)
Oil Palm/*Elaeis guineensis*	IC651993	24039	High oil to bunch percent (24.53%), dura type
Cashew/*Anacardium occidentale*	IC249899	24040	Pigmented cashew (purple colour), high TSS (11.27 B), twisted pistil
Cashew/*A. occidentale*	IC639957	24041	Cluster bearing, consistent yielder (6.9 kg nuts per tree), high yield (14.79 kg cumulative nut yield per tree at fourth harvest).
Cashew/*A. occidentale*	IC639953	24042	Jumbo nut (12 g), high yield (7.49 kg per tree)
Cashew/*A. occidentale*	IC651994	24043	Low CNSL content (7.85%) in shell of tender nut, easy to remove tender kernel from tender nut with less skin damage, high tender kernel recovery (32%), high shelling percentage (31.18%)
Cashew/*Aoccidentale*	IC250079	24044	Big size of cashew apple (183.10 g), slant nut bearing
Jackal Jujube/*Ziziphus oenoplia*	IC625864	24045	High phenol (256.2 GAE), black in colour at the time of maturity
German Chammomill/ *Matricaria chamomilla*	IC651995	24046	Fresh flower yield: 2.55 kg/plot (6 sq. m), essential oil content: 3.49 g/kg
True Lavender/*Lavandula angustifolia*	IC651996	24047	Fresh spike yield: 3.03 kg/plot (6 sq. m), essential oil content: 12.59 g/kg
Gladiolus/*Gladiolus hybridus*	IC641855	24048	Spontaneous mutant outer tepals is in yellow orange group 16 D, 2-3 spots on inner tepals in red group 46 C, high number of florets (18.66 to 19.66), greater length of spikes (>117.00 cm), high average corm multiplication rate (2.66 per plant)
Sugarcane/*Saccharum* sp.	IC651997	24049	Broad spectrum resistance to red rot disease (Cf 671 and more virulent Cf671 + Cf9401). Winter sprouting potential (WSI=7.2)
Sugarcane/*Saccharum* sp.	IC651998	24050	High winter sprouting potential (WSI=10.6). Broad spectrum resistance to red rot disease (R to Cf06 pathotype and MR to Cf06 + Cf12 mixed pathotype)
Sugarcane/*Saccharum* sp.	IC651999	24051	Red rot resistance (MR), smut resistance (MR) and yellow leaf disease resistance (MR)
Potato/*Solanum tuberosum*	IC652000	24052	High resistance to potato cyst nematode (0.97Rf). Moderate resistance to late blight disease of potato (AUDPC=134.3)
Castor/*Ricinus communis*	IC652001	24053	High 100 seed weight (35.3 g in rainfed conditions)
Rice/*Oryza sativa*	C76013	24054	Possesses resistance to Brown Plant Hopper at reproductive stage (damage score of 2.2)
Rice/*Oryza sativa*	IC75975	24055	Novel donor for resistance to brown plant hopper (damage score 2.3)
Rice/*Oryza sativa*	IC653256	24056	Novel donor for resistance to brown plant hopper (damage score is 4.2). Present in the background of IR 64
Rice/*Oryza sativa*	IC653257	24057	Novel donor for resistance to brown plant hopper (damage score <3). Present in the background of IR 64
Rice/*Oryza sativa*	IC653258	24058	Novel donor for resistance to brown plant hopper (damage score <3). Present in the background of popular variety Improved Samba Mahsuri

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Wheat/*Triticum aestivum*	IC653259	24059	Leaf and stem rust resistance [Leaf rust score (ACI=0.3-3.3); Stem rust score (ACI=0.0-2.3)]
Wheat/*T. aestivum*	IC653260	24060	Tolerance to drought (DSI=0.62) and heat stress (HSI=0.73)
Barley/*H. vulgare*	IC653261	24061	Resistance to all the pathotypes of leaf rust at seedling and adult (HSI=TS) stage. Resistance to all the pathotypes of stripe rust at seedling stage. Adult plant resistance to stripe rust with ACI=0.3, HIS=5 MR
Barley/*H. vulgare*	IC653262	24062	Adult plant resistance to yellow rust with ACI = 0.2 HIS = TMS
Barley/*H. vulgare*	IC653263	24063	Hull less barley possessing seedling resistance to all the pathotypes of yellow rust. Adult plant resistance to yellow rust with ACI less than 10 (ACI=1.3). Adult plant resistant leaf rust with highest susceptibility score of 0
Clusterbean/*Cyamopsis tetragonolobus*	IC646505	24064	Stringless pods in cluster at each node
Bitter gourd/*Momordica charantia*	IC653264	24065	First white flowered bitter gourd line developed. White flower trait is governed by single recessive gene. Good combine for fruit yield, fruits with discontinuous narrow ridges which is a desirable market trait
Bitter gourd/*Momordica charantia*	IC653265	24066	Highly stable predominantly gynoecious line of bitter gourd with high female : male flower (3:1) ratio. Fruits are long (16-18 cm), green, spiny surface with broken and discontinuous ridges those are highly preferred by the consumers
Safflower/*Carthamus tinctorius*	IC337891	24067	Moisture stress tolerance
Safflower/*Carthamus tinctorius*	IC0631963	24068	Early flowering (77 days) with high seed yield (1,763 kg/ha)
Pandan/*Pandanus amaryllifolius*	IC646223	24069	High foliage (430 g/plant/year) production in tropical high rainfall condition. Can be cooked with rice to give pleasant aroma. Foliage rich in antioxidant content [DPPH activity (80.21% RSA)]
Cashew/*Anacardium occidentale*	IC250164	24070	High bearing with unique apple to nut attachment (reduced fruit cavity depth (2.60 mm) and scar size (3.13 mm)
Cashew/*Anacardium occidentale*	IC653266	24071	Very long nuts (42.08 mm) and kernels (32.76 mm) which fall in superior kernel grade types (W120)
Cashew/*Anacardium occidentale*	IC653267	24072	Wide (broad) nuts and width of 31.26 mm which is high compared to other genotypes/accessions
Cashew/*Anacardium occidentale*	IC653268	24073	Jumbo nut type accession with lowest cashew apple to nut (AN) ratio (4.12)
Gladiolus/*Gladiolus hybridus*	IC653269	24074	Taller plant with 107.58 cm plant height, longer spikes (91.23 cm), only 61.00 days for spike initiation. Early maturing: florets showing colour in about 70.66 days. Florets pale yellow (18C as per R.H.S colour chart) with reddish spots at the base of inner tepals. Good rachis length (48.12 cm) on which flowers arranged in symmetrical manner. It produces more florets per spike (15.38)
Orchids/*Dendrobium nobile*	IC653270	24075	High quercetin (phenolic) content (1679.3 mg/kg) in stem. Contains bioactive compound Ethylamine (Embramine) and 1,6-Methanonaphthalen5(1H)-one, octahy-dro2,4a,8a-trimethyl (1S, 2S, 4aR, 6R, 8aS). These medicinally/ nutraceutically important bioactive compounds were detected for the first time in *Dendrobium nobile*
Orchids/*Dendrobium moschatum*	IC653271	24076	High quercetin (phenolic) content (4518.3 mg/kg in leaves). Contains bioactive compound Cycloheptasiloxane and Benzofuran. These medicinally/nutraceuticallly important bioactive compounds were detected for the first time in *Dendrobium moschatum*
Orchids/*Coelogyne nitida*	IC653272	24077	High quercetin (phenolic) content (2,496.6 mg/kg) in whole plant. Contains bioactive compound, 2-Pyrrolidinecarboxylic acid, 1,2-dimethyl-5-oxo-, methyl ester and Quinoline, decahydro2,5-dipropyl. These medicinally/ nutraceutically important bioactive compounds were detected for the first time in *Coelogyne nitida*
Orchids/*Arundina graminifolia*	IC653273	24078	High quercetin (phenolic) content (211 mg/kg in whole plant). Contains bioactive compound, 2DLNorleucine, N-(2-methoxyethoxycarbonyl)-pentyl ester. These medicinally/nutraceutically important bioactive compounds were detected for the first time in *Arundina graminifolia*
Marigold/*Tagetes erecta*	IC653274	24079	High in carotenoid content (2.28 g/100 g of dry petal meal), large sized double flowers with flower diameter of 6.05 cm, higher in yield (0.500 kg/ plant)
Marigold/*Tagetes erecta*	IC653275	24080	Rich in carotenoid content (2.07 g/100 g of dry petal meal). Higher number of seeds/capitulum (145.51), higher number of flowers/ plant (114.37) and is also genetic male sterile line
Potato/*Solanum tuberosum*	IC648624	24081	Improved gene donor (self-compatibility gene) diploid line for self-compatibility introgression. Profuse flowering and berry setting upon selfing
Potato/*Solanum tuberosum*	IC648623	24082	Vigrous self-compatibility gene donor diploid line. Profuse flowering and berry setting upon selfing

Crop/Botanical name	National Identity	INGR No.	Novel/Unique features
Macaranga/*Macaranga nicobarica*	IC626370	24083	Large sized and abundant leaves in tropical high rainfall conditions. Leaf lamina undivided, intact and does not tear with mild pressure besides the size of over 75 cm x 90 cm. Leaves do not have any taste or offensive smell
Indian Mustard/*Brassica juncea*	IC346692	24084	Drought tolerance (SPAD value=41.18)
Potato/*S. tuberosum*	IC653276	24085	High resistance to late blight (AUDPC value = 23)
Black Pepper/*Piper nigrum*	IC599082	24086	Highest berry recovery (37.22%)
Indian Mustard*/*Brassica juncea*	IC589658	20004	Resistance to white rust [Average resistant reaction to white rust in both UDN (8.19%) and NDN (3.23%)]

**This Indian mustard germplasm is not added in total number of registered germplasm as this has already registered with NBPGR and was approved for the extra trait.*

Horticultural Genetic Resources (HGR)

Exotic germplasm acquisition of potato: A total of 92 *in-vitro* accessions from three countries were imported, including 24 from CIP, Lima, Peru; 56 from the USA; seven from the Netherlands; and five from Germany. Additionally, 70 pest-free accessions were introduced to the germplasm repository.

Diversity in piper in North Eastern regions: Three piper species (*Piper peepuloides, P. sarmentosum* and one yet to be identified) were collected from West Khasi Hills. Further, two additional species (*Piper mullesua* and *P. haridasini*) were collected from the West Jaintia Hills. This collection highlights the rich biodiversity of the region and opens up new avenues for the study and utilization of these piper species, particularly in terms of their medicinal and agricultural potential.

Animal Genetic Resources (AnGR)

Registration of animal breeds: ICAR-NBAGR, Karnal registered seven new indigenous breeds, viz. Andmani goat, Andamani pig and Andamani duck of Andaman & Nicobar Islands; Bhimthadi horse of Maharashtra; Anjori goat of Chhattisgarh; Macherla sheep of Andhra Pradesh; Aravali chicken of Gujarat; and one synthetic breed 'Frieswal' of cattle. After registration of these breeds, total indigenous animal breeds are now 219 in the country including 53 for cattle, 20 for buffalo, 39 for goat, 45 for sheep, 8 for horses AND ponies, 9 for camel, 14 for pig, 3 for donkey, 3 for dog, 1 for yak, 20 for chicken, 3 for duck, and 1 for geese.

Phenotypic characterization of Rohilkhandi cattle: A new cattle breed Rohilkhandi was characterized in the Rohilkhand region of Uttar Pradesh, with 1,718 animals (1,298 females and 420 males) studied. The breed's coat is mainly white/grey with occasional black tinge, and it has white eyelids, grey to black horns, and black tail switch, muzzle, and hooves. Males have larger, outward-curving, tapering horns (29.5±8.2 cm) compared to females (20.5±6.9 cm). Males also exhibit a slightly higher body length (134.68±0.72 cm) than females (120.40±0.36 cm). The breed has a straight forehead, narrow dished face, and a small to medium-sized hump in females and a medium-sized hump in males. The average height at withers, chest girth, and paunch girth for males is 130.25±0.72 cm, 178.01±0.75 cm, and 182.3±16.3 cm, respectively, while for females, these measurements are 120.87±0.42 cm, 159.67±0.53 cm, and 162.8±17.5 cm. Females have a small to medium, bowl-shaped udder with cylindrical, pointed teats. The daily milk yield is 5.21±0.06 kg, with a lactation length of 210.35±1.48 days. The fat and SNF content are 4.52±0.02% and 8.00±0.014%, respectively. The reproductive performance is good, with a calving interval of 354.27±1.13 days, a service period of 80.67±1.11 days, and an age at first estrus of 32.67±0.18 months. The Rohilkhandi breed serves dual purpose, providing both milk and draught power, and has been traditionally reared by farmers in the region.

Genetic variation within Indian pig breeds: Genetic variation within Indian Pig breeds, viz. Ghungroo, Doom, Niang Megha, Agonda Goan and Manipuri black was explored using FAO ISAG microsatellite markers with 50 genetically unrelated pigs from the native breeding tract. The association of genetic variability in the form of single nucleotide polymorphism (SNP) in different candidate genes with litter size traits was explored in three Indian pig breeds.

***Ex-situ* conservation of AnGR:** Under the medium- and long-term conservation of AnGR in alignment

Mushroom diversity of Himachal Pradesh

A total of 210 collections of mushrooms were made. Out of these, 200 were identified up to genus level and approximately 100 specimens up to species level. Among these specimens, some of interesting ones are *Cantharellus cibarius, Helvella atra, Lactarius rubidus, Lactifluus volemus, Lentinus cladopus, Lycoperdom perlatum, Russula delica, Sarcoscypha coccinea, Volvariella volvacea* etc. Culturing of 6 specimens namely *Lentinus cladopus, Lentinus squarrosulus, Laetiporus sulphureus, Clitocybe* sp., *Pleurotus ostreatus, Volvariella bombycina* etc. was done.

Fruiting bodies of *Lactifluus volemus*


Basidiospores

Rohilkhandi Cattle

> **Mission towards zero non-descript AnGR of India**
>
> ICAR-NBAGR, Karnal, initiated a mission approach for identifying new homogenous animal population in various states through institute projects, in August 2021. So far, 19 Interface Meets have been held in different states/UTs, leading to the identification of 56 new potential populations. These populations are being characterized by centers across the country (ICAR institutes, SAUs/SVUs, State AHDs, NGOs, etc.) under the ICAR Network Project (NWP) on Animal Genetic Resources. Characterization, following systematic surveys with standardized questionnaires, has been initiated for 43 populations at 33 Network Centres. Additionally, an *in-situ* conservation programme for five endangered breeds (Tibetan & Karnah sheep, Zanskari horse, Halari donkey, and Mewari camel) was launched at five Network Centers in 2023-24.

with SDG Indicator 2.5.1, ICAR-NBAGR, Karnal, has successfully cryopreserved germplasm, including semen from 60 indigenous breeds and three other populations. Additionally, somatic cells from 80 indigenous breeds and five other populations have been cryopreserved at the National Gene Bank of the Bureau. The Bureau has cryopreserved the germplasm of approximately 50% of the country's indigenous breeds and is committed to preserving the germplasm of all indigenous breeds by 2030. Furthermore, the germplasm of 29 out of the 38 indigenous breeds at risk, as listed in the Breed Watch List, has been cryopreserved at the National Gene Bank.

Poultry germplasm supply: Through AICRP on Poultry Breeding a total of 10,40,567 chicken germplasm was distributed to 14,113 farmers/beneficiaries from different centres. The Mannuthy centre evaluated the S-34 generation of IWN and IWP strains of White Leghorn. AAU, Anand centre has evaluated native chicken, i.e. Ankleshwar and White Leghorn strains. The Bengaluru and Ludhiana centres evaluated PB-1 (male line) and PB-2 (female line) and native chicken populations. MPUAT, Udaipur centre evaluated Mewari and Pratapdhan populations. AAU Guwahati centre evaluated the Kamrupa variety, indigenous chicken and Dahlem Red populations. The Palampur centre evaluated the performance of Himsamridhi. The Jabalpur centre evaluated G-3 population of Jabalpur colour and Kadaknath breed. Agartala centre evaluated the performance of Tokbari, a newly developed location specific chicken for NEH region.

The ICAR-Directorate of Poultry Research, Hyderabad, has made a significant impact on the poultry sector by distributing its improved varieties across the country. During the reporting period, 83,478 hatching eggs, 2,32,894 day-old chicks, 5,662 mature birds, 40,068 units of duck germplasm were supplied. Additionally, 60,203 parent chicks of diverse breeds were delivered to farmers, government bodies, and various organizations.

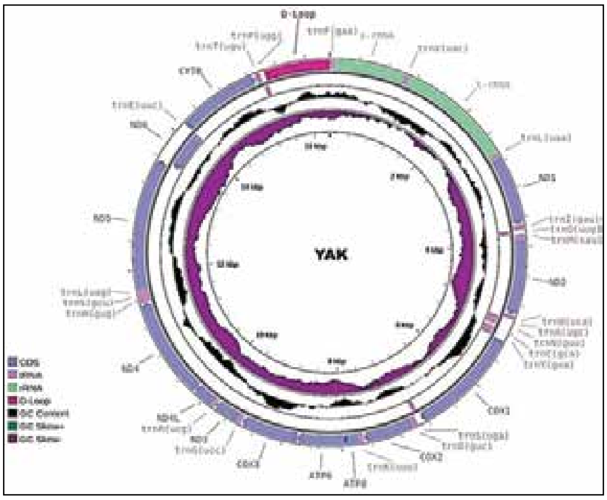
Mithun characterization and conservation: Three distinct Mithun populations (Arunachali Mithun, Manipuri Black Socks, Nagami Mithun) and Mithun × Cattle hybrids have been characterized by whole genome sequencing. Establishment and conservation of different unique Mithun populations was undertaken at Mithun Farm of the ICAR-National Research Centre on Mithun, Medziphema.

Designing of SNP chip for indigenous cattle and buffaloes: In a collaborative effort between NDDB and ICAR-NBAGR, unified genomic SNP chips for indigenous cattle and buffaloes were developed. These chips were validated using samples from a wide range of breeds, with validation carried out by both institutes. Both SNP chips are to be used for genomic selection in indigenous breeds of cattle and buffaloes.

Arunachali Mithun

Manipuri Black Socks

Nagami Mithun



Complete mitogenome structure of first Indian yak breed 'Arunachali' developed by ICAR-NRC on Yak, Arunachal Pradesh

Genome wide identification of SNPs: Candidate genes associated with cattle QTLdb (www.animalgenome.org) were identified. A total of 1,841 SNPs were annotated in 207 candidate genes responsible for various milk production and reproduction traits.

Fish Genetic Resources (FGR)

New records of fish and shellfish species from the Indian waters: Two new species of Congrid eel, belonging to genus *Ariosoma*, were discovered. The species obtained from Gulf of Mannar, Tamil Nadu was named, *Ariosoma kannani* and the species from Kochi coast, Kerala was named *Ariosoma gracile.* The holotype specimens of both new species are registered at the National Fish Museum-cum-Repository.

A new fish species *Opsarius siangi,* was identified from Siang River, Arunachal Pradesh based on its morpho-meristic, genetic and phylogenetic characters. Further, species delimitation approach BIN and bPTP also supported *O. siangi* as a distinct species.

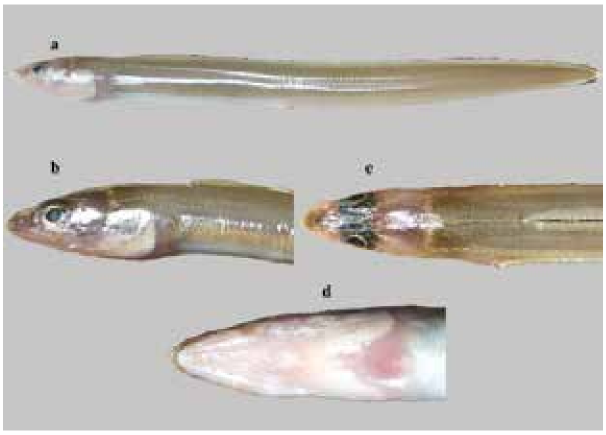
Indian frogfish, *Antennarius indicus* was recorded for the first time from Hooghly-Matlah estuarine system, West Bengal. A single specimen (97.87 mm in length and 33.48 g in weight) of the species was collected in winter bagnet fishery catch at Fraserganj at prevailing estuarine salinity of 26.8 g/L.

Electric ray*, Narcinet imlei* was documented for the first time from Rushikulya estuary, Odisha having salinity level of 8.15 g/L. The specimen was collected from shore seine net deployed at a depth of 2.0–2.2 m.

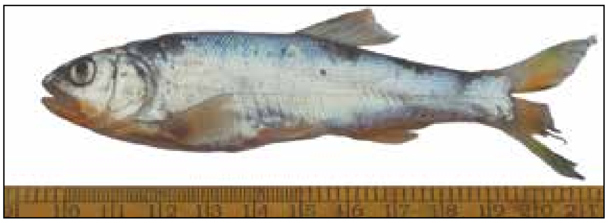
Two cyprinids fish species, viz. *Chagunius nicholsi* and *Opsarius dogarsinghi* were recorded for the first time from Torsa River, Jaldapara National Park, West Bengal. The specimens were collected from the river stretch at Kodalbasti region in gill net (mesh size 30 mm) catch.

Genetic characterization: Whole genome of Indian major carp, *Cirrhinus mrigala*, commonly known as mrigal, has been sequenced and assembled, by ICAR-NBFGR under ICAR-Consortium Research Platform on Genomics. The assembled whole genome of fish is 1.057 Gb in size, comprising 940 scaffolds with N_{50} of 37.32 Mb and was assessed to be 98% complete upon benchmarking with BUSCO. The largest 25 scaffolds

Ariosoma gracile

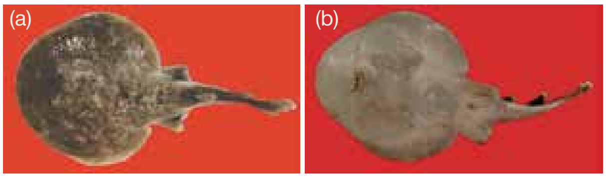


Ariosoma kannani

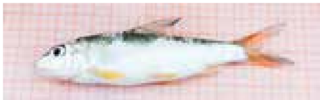


Opsarius siangi sp. nov. (holotype, ZSI FF 9339, 91.84 mm SL)

Antennarius indicus



Dorsal (a) and ventral (b) view of *Narcinet imlei*

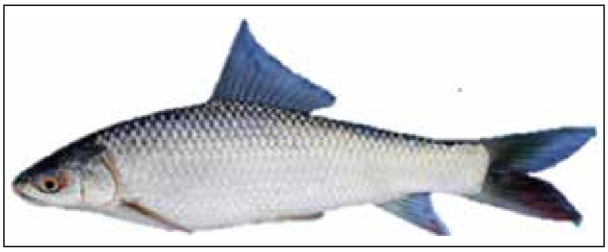


Chagunius nicholsi

Opsarius dogarsinghi

contain 960 Mb with N_{50} of 38.48 Mb with 96.30% completeness. The characterization of assembled highly revealed 39,091 genes were functionally annotated, which included 8,428 hypothetical and 1,688 uncharacterized. The present genomic information offers an important resource for mining and discovery of genes and variants for desired economically important traits of this fish. The resources make the way for the application of genomic selection programmes in aquaculture and fisheries, which will contribute significantly in genetic improvement of farmed fish for sustainable production.

Complete mitochondrial genome sequences of two small indigenous catfish species of Bagridae family, viz. *Mystus gulio* and *M. cavasius* were characterized. Samples of *M. cavasius* were collected from Ganga, Krishna, Cauvery, Brahmaputra and Mahanadi rivers and that of *M. gulio* were collected from Ganga and Mahanadi rivers and a hatchery in Naihati, West Bengal. Mitochondrial genomes of both the species were circular



DNA molecules of 16,554 bp in length. These complete mitochondrial genome sequences *M. cavasius* and *M. gulio* have been submitted in GenBank with an accession number OP893799 and OP856487, respectively. The *Mystus* species mitogenomic organization consisted of 37 genes in total, including 13 protein-coding genes (PGCs), two ribosomal RNA (rRNA), 22 transfer RNAs (tRNAs), and a D-loop regulatory region which is comparable to that of typical vertebrate or other fish mitogenomes, which indicates that mitogenomes may be highly conserved throughout the evolutionary process.

Asian green mussel, *Perna viridis* is an important aquaculture species in the family Mytilidae. High-quality chromosome-level assembly of this mussel was generated by combining PacBio single molecule sequencing technique (SMRT), Illumina paired-end sequencing, high-throughput chromosome conformation capture technique (Hi-C), and Bionano mapping. Final

(A) *Mystus cavasius* and (B) *Mystus gulio*

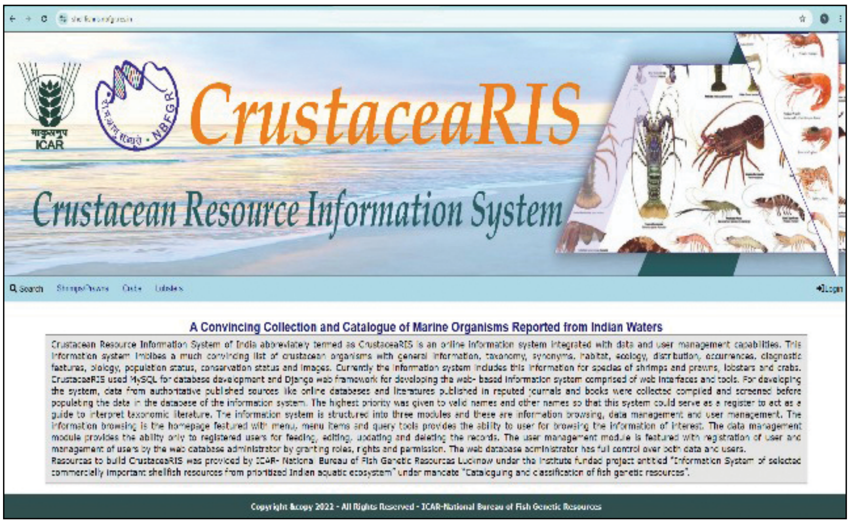
assembly resulted in a genome of 723.49 Mb in size with a scaffold N_{50} of 49.74 Mb with 99% anchored into 15 chromosomes. A total of 49,654 protein-coding genes were predicted from the genome. The presence of 634 genes associated with cancer pathway and 408 genes associated with viral carcinogenesis indicates potential of this species to be used as a model for cancer studies. Chromosome-level assembly of this species is also a valuable resource for further genomic selection and selective breeding for improving economically important aquaculture traits and augmenting aquaculture productivity.

Crustacea RIS (An online information system for crustacean resources of India): An online information system for crustacean resources, accessible at https://shellfishris.nbfgr.res.in, covers information of crustaceans such as crabs, lobsters, shrimps and prawns reported from Indian waters. Presently, the system contains information on 506 species of shrimps and prawns belonging to 152 genera (31 families) known from the Indian waters, 872 species of crabs belonging to 416 genera (74 families) and 23 species of lobsters belonging to 6 families (13 genera) along with their distributional range.

HilsaTranscripSSRDB (An online transcriptome database of Hilsa): An on-line database HilsaTranscripSSRDB: A Dynamic Search Tool was developed for transcriptome data of Hilsa shad, *Tenualosa ilisha,* with user-friendly interfaces to make the information easily available to researchers, for promotion of research at transcription level. It is hosted at https://www.nbfgr.res.in:802/index.aspx. It is a searchable database, based on transcriptomes of Hilsa shad from five tissues, viz. muscle, kidney, liver, testis and ovary and simple sequence repeats present in the transcripts.

Microbial Genetic Resources

Microbial genetic resources collection: The ICAR-National Agriculturally Important Microbial Culture Collection (NAIMCC), now holds 8,500 microbial accessions representing actinomycetes, bacteria, fungi and cyanobacteria. During period of report, 604 microbial strains were accessioned and preserved. A total of 40



different bacterial and five different fungal species have been newly added to the repository. The NAIMCC has supplied 119 microbial cultures to various private and public sector institutions for research purposes. A total of 21 microbial cultures have been accessioned under safe deposition from different public and private sector institutions. Additionally, nine microbial cultures were accessioned as patent deposits.

DNA Fingerprinting of microbes: To maintain the authenticity of biopesticides and to check the spurious and substandard products, the Central Insecticide Board and Registration Committee (CIB & RC) has included molecular identification and DNA fingerprint as mandatory requirements for registration. Accordingly it has recognized ICAR-National Bureau of Agriculturally Important Microorganisms (NBAIM), Mau, as the nodal agency for developing DNA fingerprints of microbial cultures to be registered as biopesticides. More than 450 samples from 118 companies and biopesticide units under SAUs were processed for fingerprinting at ICAR-NBAIM. The samples mainly contained *Trichoderma harzianum, T. asperallum, Beauveria bassiana, Metarhizium anisopliae, Verticillium lecanii, V. chlamydosporium, Paecilomyces lilacinus, Pseudomonas fluorescens, Bacillus thuringiensis, B. subtilis* etc.

Insect Genetic Resources

Germplasm collection: The ICAR- NBAIR museum now holds around 2.80 lakh specimens with addition of 34,786 insect specimens. Thirty nine species of insects and one species of spider which are new addition, were collected and described. Majority of these species were recovered from the biodiversity hotspot areas such as Western Ghats, Eastern Ghats, North Eastern states and Andaman & Nicobar group of Islands. All these new discoveries were formally named and described in scientific journals. The new discoveries are important since millions of insect species on the planet are on the brink of extinction due to profound anthropogenic impacts. The discoveries help greatly in understanding the biodiversity and managing the insect pests in India.

DNA Fingerprinting of insects: DNA barcode for 327 insect species and whole genome sequencing for 12 species including two insects, five Bt and EPN strains each were generated. Thirty three stage/age/tissue specific transcriptomes (18 insects, and 10 EPN samples) were generated and analysed for the characterization of different genes and gene families. Important gene families of insects, EPNs and entomopathogenic microbes (Bt) were mined from the genome and transcriptome datasets, and many novel genes were observed as a target for RNAi and genome editing.

❑

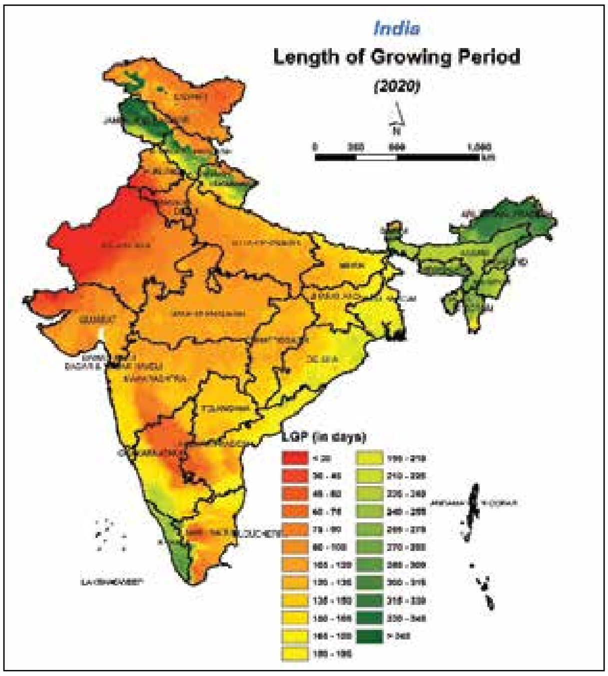
8.
Soil and Water Productivity

Slope and crop cover maps of India are very important to estimate soil erosion by considering climatic conditions, soil properties, topography, crop and soil management practices. C-factor map of India, one of the most important parameters, was made using land use and land cover map of India. Slope map of India was prepared using ASTER DEM (30-m resolution) for estimating the P-factor map of India. The nutrient balance is defined as the difference between the nutrient inputs entering a system and the nutrient outputs leaving the system, i.e. nutrients uptake by crop. Data related to partial N, P, K balance application revealed that N had a positive balance in all the treatments except control. The highest positive balance was observed with 150% NPK. Similarly, the partial balance for P indicate a positive balance in all treatments except 100% N and control. The lowest balance was recorded with 100% N and the highest was observed in 150% NPK. All treatments had a negative partial balance except 150% NPK. The lowest partial balance was found with 100% NP while the highest was recorded with 150% NPK. The full N, P and K balance emanated from the NUTMON model depicts the value from 30.70 to 22.32 kg ha^{1}. Conventional soil testing is time-consuming, labour-intensive, and expensive. Hence, efforts are being made across the globe to develop rapid and less expensive methods of assessing soil health parameters. One promising approach is spectroscopic soil analysis, an emerging technology that enables the rapid, non-destructive, and cost-efficient characterization of soil health indicators. Among the different properties evaluated, soil organic carbon, pH, sand, silt and clay content, soil water retention capacity at field capacity and permanent wilting point were predicted with reasonably good accuracy. This technique has the potential for its application in precision agriculture, monitoring soil quality in landscapes, and digital soil mapping.

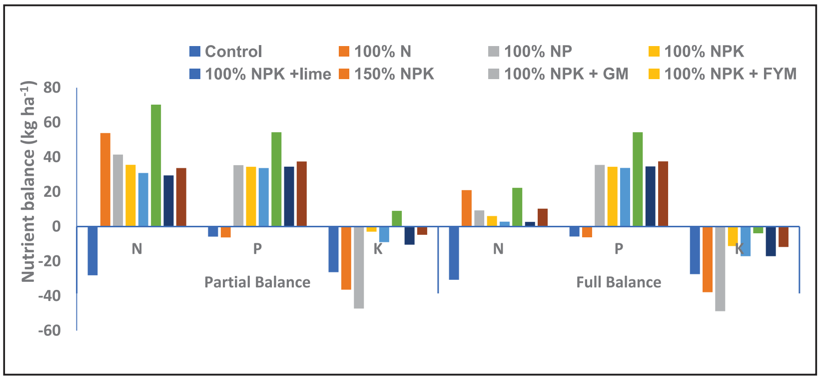
Tools and Models for Estimating Soil, Nutrient and Water Status

Spatial modeling for agro-ecological zones (AEZs) of India: A study was conducted to delineate AEZs in India using earth observation time-series data. The Length of Growing Period (LGP) map, created at 15-days interval, was developed by integrating India's mean annual potential evapotranspiration (PET) and soil available water capacity (AWC) maps. The LGP map identified 23 classes, ranging from hyper-arid zones with an LGP of less than 30 days (mainly in western Rajasthan) to per-humid zones with an LGP of more than 345 days (mainly in North-eastern India). By combining bioclimatic zones and LGP maps using GIS tools, initially 116 bioclimatic and LGP class combinations were initially identified. After merging smaller areas (< 1,000 ha) with adjacent zones, 97 distinct classes were finalized. Terrain parameters, such as elevation and hill shade derived from 30 m resolution DEM data (SRTM), were used during the generalization process. The largest area is covered by the semi-arid moist zone with an LGP of 105–120 days, while the smallest area is in the semi-arid moist zone with an LGP of 75–90 days. The 2020 LGP map of India, provides valuable insights for agricultural planning and resource management.

Estimation of nutrient balance (N, P and K) using the NUTMON model: The nutrient balance measures the difference between the nutrient inputs entering a system and the nutrient outputs leaving the system, i.e. nutrients uptake by the crop. A study evaluated the partial and full nutrient (N, P and K) balance application under different conditions. It revealed that for N, partial balance ranged from -28.10 kg/ha (control) to 70.21 kg/ha (150% NPK).



Length of growing period (LGP) map of India (2020)



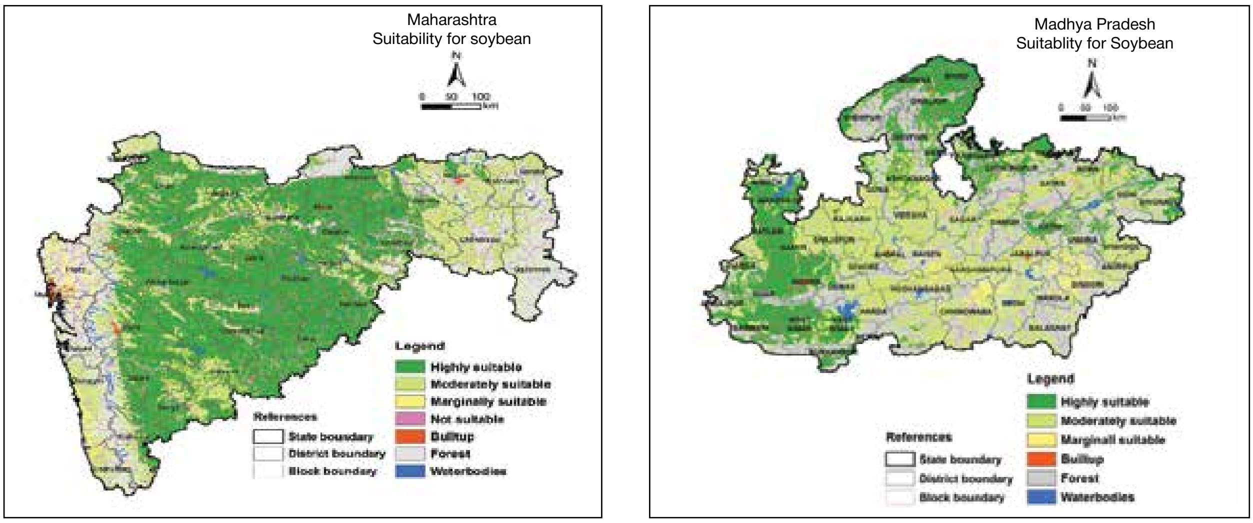
Estimates on nutrient balance (N, P and K) under LTFE as predicted by the NUTMON tool box (Pattambi, Kerala)

All treatments except the control had a positive balance. Full balance values varied from -30.70 to 22.32 kg/ha, with the lowest in the control and the highest in 150% NPK. Similarly, the partial balance for P varied between -6.29 kg/ha (100% N) and 54.31 kg/ha (150% NPK). Full balance values ranged from -6.19 to 54.31 kg/ha, with positive balances in all treatments except 100% N and control. The partial balance of K varied from -47.28 kg/ha (100% NP) to 9.03 kg/ha (150% NPK). Full balance showed negative values for all treatments, ranging from -27.44 kg/ha (control) to -3.87 kg/ha (150% NPK). The persistent negative balance for K indicates its potential depletion under long-term intensive cropping. Based on the study, NPK recommendation for rice crop cultivation in Kerala should be revised to ensure sustainable nutrient use and soil health.

Mid-Infrared (MIR) spectroscopy for rapid soil health assessment: Understanding soil health is crucial for developing a productive and sustainable farming system. Traditional soil testing methods are slow, costly, and labour-intensive, requiring many samples to capture spatial and temporal variations in soil health. To address this, spectroscopic soil analysis is emerging as a rapid, non-destructive, and cost-effective alternative. A study was conducted to analyze around 2,500 soil samples from major soil types like Alfisols, Vertisols, and Inceptisols, covering about 62% of India's geographical area. Spectral signatures (2.5–25 µm) were generated to identify important soil health indicators. Machine learning techniques such as Partial Least Squares Regression (PLSR), Support Vector Machines (SVM), and Random Forest Regression were used to estimate properties like soil organic carbon, pH, sand, silt and clay content, soil-water retention capacity at field capacity and permanent wilting point with reasonably good accuracy. This technique has the potential for its application in precision agriculture, monitoring soil quality in landscapes, and digital soil mapping.

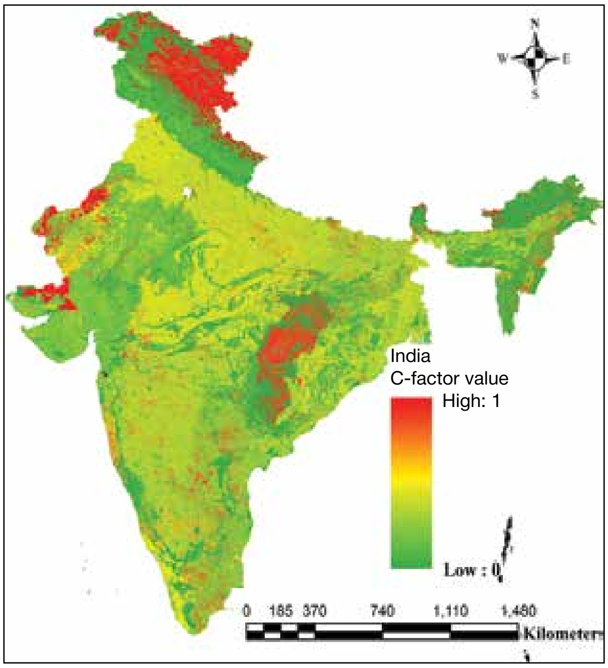
Delineation of potential areas for soybean cultivation using GIS modeling techniques: A study was conducted across 15 states to identify potential areas for soybean cultivation using GIS modeling techniques. Climate and soil-based input parameters were generated and integrated within a GIS framework to map suitable areas for soybean cultivation. Advanced GIS techniques were used to develop and test criteria and weights for input parameters, focusing on Madhya Pradesh and Maharashtra. In Madhya Pradesh, the analysis identified 9.30 million ha as highly suitable, 18.5 million ha as moderately suitable, and 1.00 million ha as marginally suitable for soybean cultivation. Whereas, in Maharashtra, about 16.3 million ha area was identified highly suitable, 10.8 million ha as moderately suitable and 1.60 million ha as marginally suitable for soybean cultivation. This GIS-based approach provides a robust tool for identifying and optimizing land use for soybean cultivation.

Land resource inventory (LRI) card: LRI cards provide vital information on climate, soil fertility, site-specific crops, and recommended technologies to improve productivity and conserve soil and water.

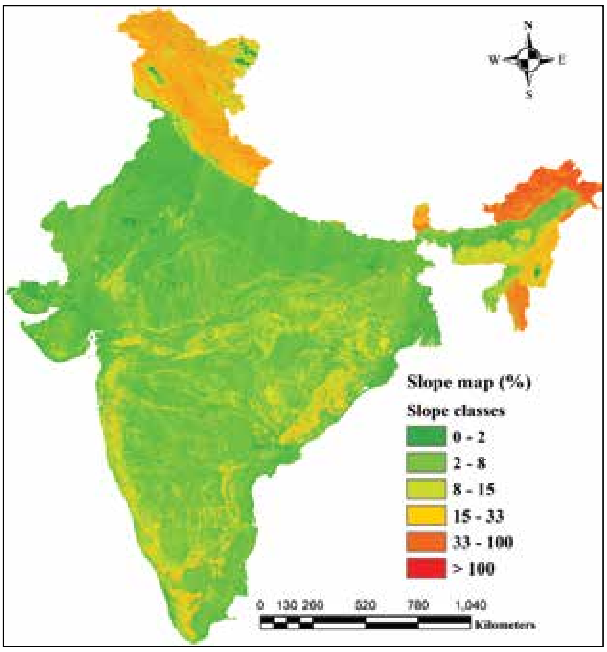


Suitability maps of soybean for Maharashtra and Madhya Pradesh

Around 1.50 lakh LRI cards and 102 micro-watershed Atlases were created for farmers in 102 micro-watersheds of Sambalpur and Koraput districts, Odisha, covering 75,419 ha at a cadastral scale of 1:8,000 using automated methods. These resources were handed over to the Government of Odisha, benefiting over 1.50 lakh farmers by supporting detailed crop planning to enhance livelihood security. In Karnataka, LRI atlases (in Kannada and English), sub-watershed reports, and individual survey number-based LRI cards (in Kannada) are being prepared for nearly 15 lakh farmers. To support ongoing capacity building, data dissemination, and updates, the Advanced Centre for LRI Technology (CoE-WD) has been established at the University of Agricultural Sciences, Bengaluru.



C-factor map of India

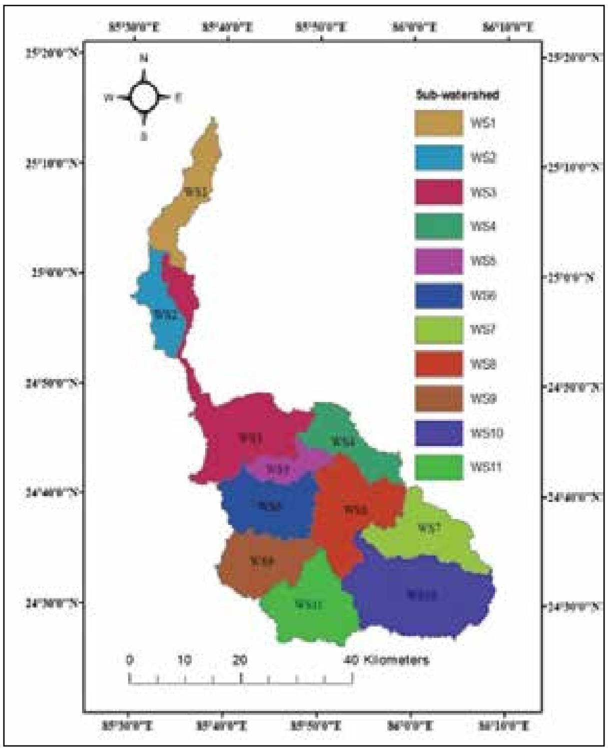


Slope map of India

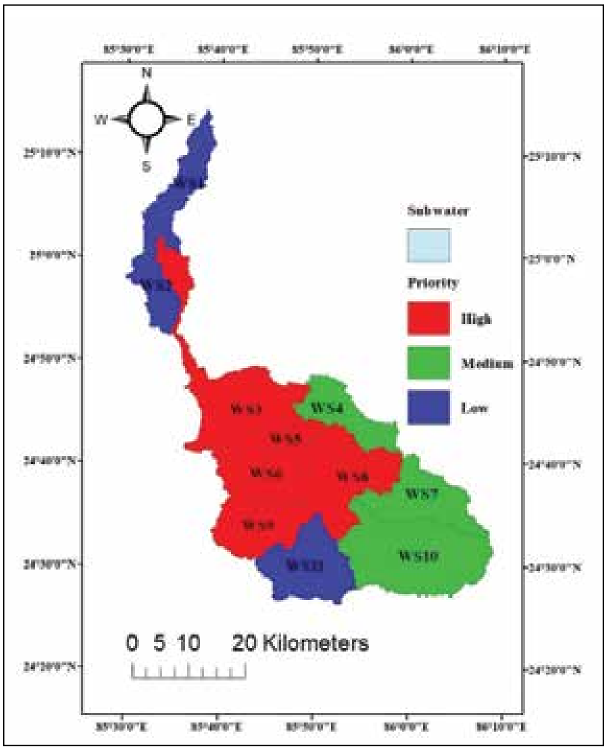
Development of C-factor and slope map of India: The C-factor and Slope cover maps of India are very important to estimate soil erosion under varying climatic, soil, topographical, and management conditions. Accordingly, a C-factor map of India was created using land use and land cover data, making it a crucial parameter for soil erosion studies. Slope map of India was prepared using ASTER DEM (30-m resolution) for estimating the P-factor map of India. Based on the plot scale study, for different conditions, conservation management practice (P-factor value) was also estimated. These maps contribute significantly to understanding and managing soil erosion across India.

Integrated modeling for drought management strategies: A study in the Sakri River basin analyzed rainfall and temperature changes over 30 years (1991–2020) using the Mann-Kendall test and Sen's slope. Annual and monsoonal rainfall showed an increasing trend, with monsoon rains contributing about 84% of the total annual rainfall. Annual rainfall varied from 2.26 to 7.63 mm/year, with percentage changes of 0.84–2.27%. Significant temperature increases were observed in September (monsoon) and April (pre-monsoon), except at specific stations. The study prioritized 11 sub-watersheds using morphometric and PCA techniques based on 17 geomorphometric parameters. High-priority sub-watersheds (SW3, SW5, SW6, SW8, and SW9), covering 46.8% of the basin, were identified as at high risk of erosion. Immediate soil and water conservation efforts are recommended for these areas to reduce erosion risk and mitigate drought impacts.

Delineation of management zones for site-specific soil nutrient management: Soil nutrient deficiencies significantly contribute to soil degradation and reduce crop productivity. Delineating soil nutrient management zones (MZs) is an effective approach to evaluate the spatial variability of soil properties for adopting site-specific nutrient management strategies. A total of 18,930 surface soil samples (0–15 cm depth) were collected from the north-western Indian Himalayan (NWIH) region. Samples were analyzed for 13 soil parameters, including pH, EC, SOC, available N, P, K, exchangeable Ca and Mg, available S, Zn, Fe, Cu, Mn, and B. Soil parameter values showed high variability (coefficient of variation: 11.8–156%). Semi-variogram analysis revealed stable, exponential and Gaussian best-fit models for different soil parameters with weak (P and B), moderate (rest of soil parameters), and strong (S) spatial dependence. Varied distribution pattern of soil parameters was visualized from ordinary kriging interpolation. Five MZs were delineated using PCA and fuzzy c-means clustering, considering principal components with eigenvalues >1. The identified MZs exhibited significant differences in soil properties. These maps are instrumental for precise agronomic input management, especially fertilizers, to enhance environmental and economic efficiency and support sustainable crop production.

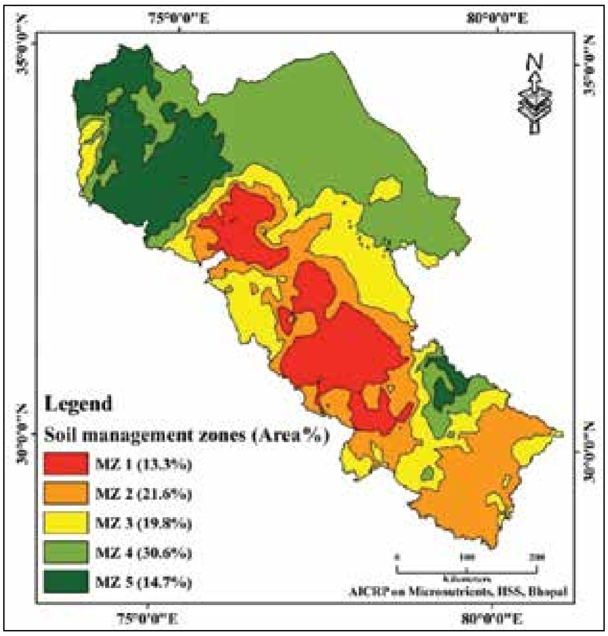


Location of the study area with sub-watershed segments



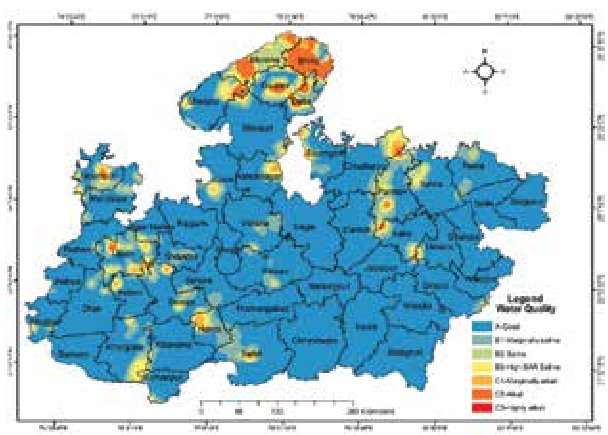
Priority of sub-watershed based on morphometric analysis

Groundwater quality for irrigation purpose in Madhya Pradesh: A new groundwater quality map for irrigation purposes has been created for Madhya Pradesh. The map includes parameters such as Electrical Conductivity (EC), pH, Sodium Adsorption Ratio (SAR), and saline/alkali water categories. Data from the AICRP on managing salt-affected soils and the use of saline water in agriculture, along with data from the Central Ground Water Board, New Delhi, were used with GIS and RS software (ArcMap GIS software 9.3.1) to prepare the map. In total, 6,483 groundwater samples were analyzed. In Madhya Pradesh, 87.3% of the samples were classified as good (A), 7.70% as saline (B), and 5.0% as alkali (C) water. Among the 11 agro-climatic zones in the state, 7 had good quality water in more than 90.0% of the samples.

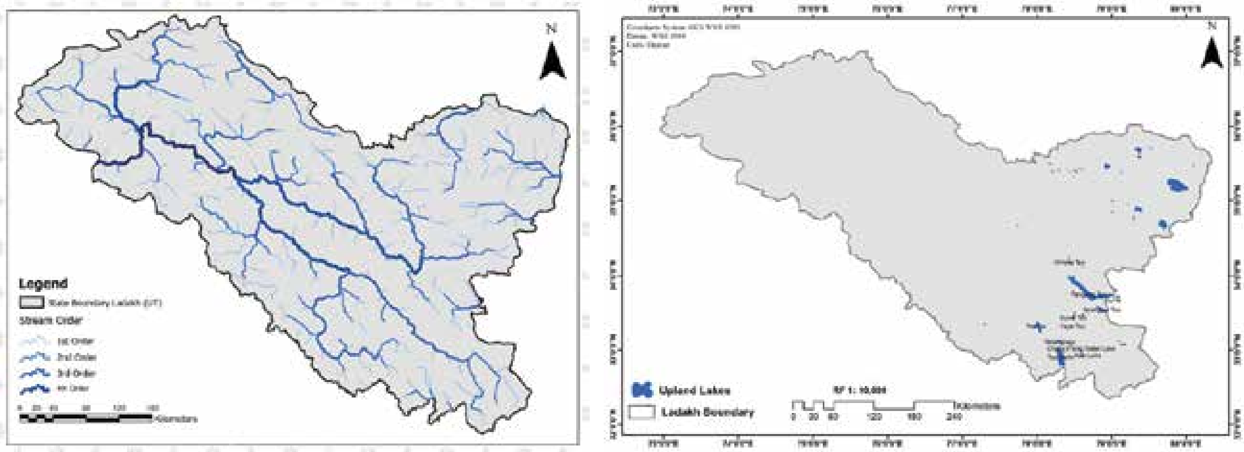


Soil nutrient management zones of the north-western Himalayan region

Mapping of aquatic resources: Effective planning in aquaculture operations relies heavily on mapping aquatic resources. Using remote sensing data and GIS techniques, the riverine and lacustrine resources of Ladakh were mapped. Images from the Linear Imaging and Self Scanning Sensor (LISS-III) were procured from NRSC Bhuvan from 10 September to 10 October 2023, covering 373 titles (https://bhuvan-app1.nrsc.gov.in/bhuvan2d/bhuvan/bhuvan2d.php). Additionally, Shuttle Radar Topography Mission (SRTM) DEM data, accessed on 10 November 2023 (https://opentopography.org/), were used to analyze resource distribution using ArcGIS



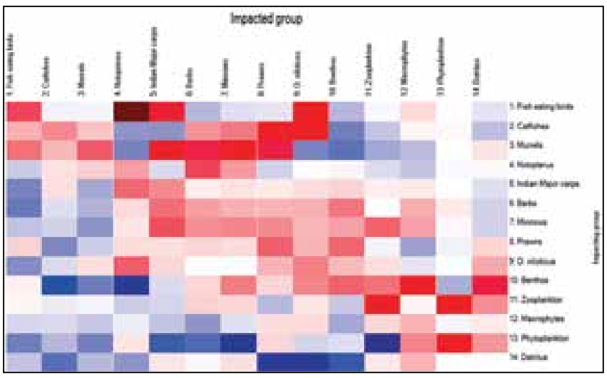
Groundwater quality map for irrigation purpose in Madhya Pradesh



Riverine network (*left*) and Upland lakes (*right*) of Ladakh

Pro 3.0 software. Preliminary results revealed a total river network of 663 streams with an aggregate length of 7,923 km, and approximately 90 lacustrine water bodies covering 98,082.71 ha.

Ecological modeling of Gayatri reservoir: The Gayatri reservoir in Karnataka, covering 785 ha at Full Reservoir Level (FRL), was evaluated for its potential in fishery enhancement using Ecopath with Ecosim (EwE) software. The study classified the reservoir's food web into 14 ecological groups, including the top predator (fish-eating birds), seven fish groups, three invertebrates, two primary producers, and detritus. The reservoir hosts 32 fish species, categorized by their catch abundance and commercial importance. Estimated biomasses were 4.74 tonnes/km² for prawns, 4.50 tonnes/km² for Indian major carps (IMCs), and 4.90 tonnes/km² for *Oreochromis niloticus*. Each group's biomass was increased in varying amounts to assess its impact on other groups. The model suggested a carrying capacity increase for prawns by 25%, *O. niloticus* by 10%, and IMCs by 75%. The reservoir's annual carrying capacity (total system throughput) was estimated at 6,453.96 tonnes/km². A primary production/respiration value of 6.12 and a system overhead value of 61.93% indicated that the ecosystem is still developing and not fully resilient to disturbances. The trophic model revealed that the reservoir relies heavily on external energy inputs despite having strong primary production.



Mixed trophic impacts in Gayatri reservoir food-web quantifying the impact of predators on prey group. The blue boxes show positive impact and the red box shows negative impact.

Products and Technologies for Remediation/Alleviation of Soil/Water Resources

Preparation and characterization of municipal sludge biochar (MSB) products: Municipal sludge (MS) poses an environmental threat due to the emission of pollutants like pathogenic organisms, organic compounds, and heavy metals, endangering soil, ecosystems, and human health. Efficient disposal of MS is essential, and converting it into biochar offers a promising solution for waste management and crop production. MS was collected from the landfill site of a sewage treatment plant in Sehore, Madhya Pradesh, and processed into biochar using a batch-type tubular stainless steel pyrolyzer at the ICAR-CIAE, in Bhopal. The pyrolyzer, with an internal diameter of 100 mm and a length of 600 mm, processed 1 kg of dried MS per batch. Parameters were optimized to 450°C temperature and 2 h residence time, resulting in a 40% biochar recovery. The produced MSB was air-dried and characterized following standard protocols. Results showed that the pH of MS and MSB were 6.54 and 6.84, respectively. Electrical conductivity (EC) for MS and MSB were 3.77 and 1.59 dS/m, respectively. Additionally, fecal coliform was absent in MSB, compared to 4.7×10^3 MPN/g in MS as per APHA 23rd Edition method.

Municipal sludge biochar

Methylotrophs bio-formulation for alleviating UV radiation stress: Agricultural production faces significant challenges from abiotic stress factors, particularly UV radiation due to ozone layer depletion and rising greenhouse gases. Addressing this issue requires a multifaceted approach, and a promising solution is a microbial product designed to alleviate UV radiation stress. *Methylobacter radiotolerans* N39, a pink-pigmented methylotroph bacterium, was isolated for this purpose. This bacterium produces a pink carotenoid pigment, mainly beta-carotene, which helps it resist UV radiation. The bacterium's beta-carotene production ranges from 0.45 to 3.09 µg/ml/d and is stimulated by UV exposure. The carotenoid extract from Methylobacter N39 enhanced UV resistance in *E. coli* by 15.0% and protected rhizobium from UV radiation. Additionally, it improved nodulation and growth in legumes, such as in pigeonpea and soybean, by 40.0 to 50.0%. Foliar applications of N39 cells or their carotenoid extract increased pigeonpea resistance to UV radiation (254 nm, 20 W/cm²/s), reducing negative effects by 50.0 to 60.0%. This product offers a strategy to manage UV radiation stress in agriculture and has potential for healthcare applications. The formulation is recommended for foliar application at 0.1–1% v/v, at 100 litre/ha. The spray protects plants like pigeonpea and soybean from UVC exposure by up to 60.0%. When used as a seed coating at 20–50 ml/kg of seed, it enhances crop yields by up to 10%. The formulation has a shelf- life of over one year when stored at room temperature.

Methylo CropCare

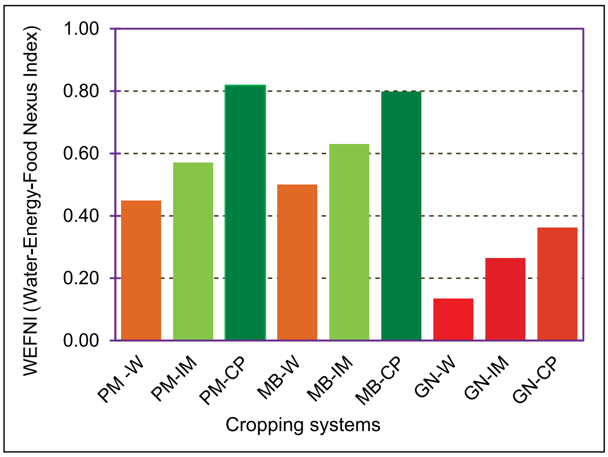
Halo-MIX - A microbial consortia formulation for salt-affected soils: This bio-formulation of halophilic plant growth promoters and nutrient mobilizers is cost-effective, eco-friendly, and effective in improving soil fertility and enhancing crop yields by mitigating adverse effects of salts and maintaining soil health. The technology is licensed through Agrinnovate India, New Delhi to M/s Sri Bio Aesthetics Pvt Ltd, Hyderabad, Telangana for commercial-scale production and marketing.

Remediation technology for minimizing Cd, Pb and Cr toxicity using modified fly ash: Weathered fly ash samples from Singrauli were hydrothermally modified in two ways: (i) the ash sample was treated with 3 N HCl at 90–95°C for 48 h with occasional stirring, followed by washing with distilled water (AcMFA); (ii) the ash sample was treated with 3 N NaOH at 90–95°C for 48 h with occasional stirring, followed by washing with distilled water (AlMFA). The cation exchange capacity (CEC) of AlMFA increased to 113 meq/100 g, compared to 2.40 meq/100 g for AcMFA and 3.40 meq/100 g for untreated ash (UFA). The sorption of heavy metals

Halo-Mix

increased with pH. AlMFA completely removed Cd and Pb due to high CEC, while acid treatment reduced their sorption at pH 5.0 and 7.0. The XRD and FTIR results showed that mineralogical changes during alkali treatment might have helped Cd and Pb adsorption. The alkali-treated fly ash exhibited structural changes in Si-O-Fe bonding and allophane mineral formation. Applying modified fly ash at 5.0% mitigated Cd toxicity and improved spinach biomass growth by more than 15.0% compared to uncontaminated soil. AlMFA reduced DTPA-extractable Cd by over 28.0% and spinach leaf Cd by 45.0%. Thus, the application of alkali-modified fly ash as a soil amendment has greater potential in reducing the mobility of heavy metal in soil and its subsequent transfer to edible plant parts (spinach leaf) as evidenced by the reduction in DTPA extractable Cd and Pb in soil and lower transfer coefficient value in a Cd and Pb contaminated soil.

Water-energy-food nexus of irrigated cropping systems of hot arid region: Field experiments at ICAR-CAZRI, in Bikaner, Rajasthan, were conducted for two years (2022-2024) to analyze productivity, water, and energy use in nine irrigated cropping systems. The systems studied were pearl millet-wheat (PM-W), pearl millet-Indian mustard (PM-IM), pearl millet-chickpea (PM-CP), mungbean-wheat (MB-W), mungbean-Indian mustard (MB-IM), mungbean-chickpea (MB-CP), groundnut-wheat (GN-W), groundnut-Indian mustard (GN-IM), and groundnut-chickpea (GN-CP). The goal



Water-energy-food nexus index (WEFNI) of irrigated cropping systems of hot arid region was to find suitable systems balancing water use, energy consumption, and food production in hot arid regions with groundwater irrigation. Main product and biomass yields varied significantly. Yields ranged from 3.11 to 6.64 Mg/ha, averaging 4.74 Mg/ha. Groundnut systems produced 18.0% and 41.0% more yield than pearl millet and mungbean systems, respectively. Irrigation water use ranged from 2,750 to 7,725 m^3/ha, with groundnut systems consuming 81.0% more water. Energy input ranged from 19.8 × 10^3 to 53.9 × 10^3 MJ/ha, with groundnut systems using 56.0% to 70.0% more energy. Net energy produced ranged from 88 × 10^3 to 203 × 10^3 MJ/ha. Groundnut-wheat and groundnut-Indian mustard systems had the highest energy output. However, pearl millet systems had higher energy-use efficiency (6.40) compared to mungbean (5.40) and groundnut (5.10) systems. Despite high energy output, groundnut-wheat had the lowest energy-use efficiency. The water-energy-food nexus index (WEFNI) ranged from 0.13 to 0.82. Groundnut-wheat had the lowest WEFNI, while pearl millet-chickpea and mungbean-chickpea systems performed better. Overall, pearl millet and mungbean systems are more suitable than conventional groundnut systems when considering water, energy, productivity, and economic returns.

Diversified legume-oilseed cropping system for synergistic enhancement of yield and water-use efficiency (WUE): Integrating legumes and oilseeds into double cropping systems offers a viable solution for optimizing land use and improving productivity under precipitation-limited conditions. Cropping systems (greengram, cowpea, blackgram, sesame, safflower), with and without rainwater management, were evaluated and it was found that rainwater management significantly enhances crop growth, biomass accumulation, and overall yield, with safflower and sesame showing the highest adaptability to moisture stress. In terms of greengram equivalent yield, the cowpea-sesame system with rainwater management achieved the highest mean yield of 1,508 kg/ha, highlighting the critical role of rainwater management in enhancing crop productivity in semi-arid regions.

Mechanism of plant resilience to water stress: Zinc (Zn) foliar spray in nano form was investigated as a potential solution to ameliorate water deficit stress in light of the electron transport system in Photosystem II (PSII) through chlorophyll *a* fast fluorescence kinetics and non-photochemical quenching (NPQ), along with pigment dynamics in response to water stress. It was found that water stress created a “traffic jam” in the electron transport system of PSII led to a decline in photosynthetic efficiency. However, treatments with Zn nano (particle size <90 nm) at 20 mg/L and Zn EDTA (solid material size ~100 mm) at 240 mg/L effectively alleviated water-deficit stress by positively influencing flux ratio parameters, including the quantum yield for electron transport (φE_0), probability of electron transport beyond QA (ψ_0), and quantum yield of electron transport from QA^- to PS I end electron acceptors (ϕR_0). The treatment also improved chlorophyll content and xanthophyll components, such as violaxanthin, antheraxanthin, and zeaxanthin, while reducing NPQ and the de-epoxidation state.

Green technology for achieving net zero emission in coastal lowland: Adopting a single wet tillage (puddling) with residue retention (RTR) in the rainy (*kharif*) season, followed by direct-seeded rice and cotton under RTR in the winter (*rabi*) season, is the most energy-efficient and carbon-positive method for double-cropped rice systems in coastal areas. The average rice equivalent yields for rice-rice and rice-cotton systems under reduced tillage were 9,181 kg/ha/yr and 8,240 kg/ha/yr, 15.0–26.0% higher than traditional yields. Zero tillage requires 15-16 more man-days for weed management. For direct-seeded rice in the *rabi* season, crop duration reduced by 10 days in rice-rice systems. Reduced tillage with residue (RTR) used 20-22% less energy than conventional methods. Over seven years, soil organic carbon (SOC) concentration in 0-100 cm soil depth increased from 2.64 to 2.94 g/kg in RTR plots. Bulk density decreased from 1.45 to 1.43 in the top 0-5 cm soil layer. The SOC pool in the top 0-20 cm rose from 15.24 to 18.2 Mg/ha, an increase of 6.50%. Overall carbon sequestration rates were 0.69 and 0.45 Mg/ha/yr for rice-rice and rice-cotton systems. The carbon footprint (CF) for RTR was 0.80 and 0.62 for rice-rice and rice-cotton systems, compared to 1.19 and 1.14 for conventional tillage. Evaluations of the net ecosystem carbon budget (NECB) and greenhouse gas budget (GHGB) showed that rice-based systems in coastal areas acted as carbon sinks (NECB: 1523 and 944 kg C/ha/yr in rice-rice and rice-cotton systems respectively), except RTR, which was a GHG sink (-68 to -228 kg CO^2-eq/ha/yr). Integrated GHG assessments showed rice-based double-cropping under reduced tillage with residue recycling as a significant GHG sink due to

Reduced tillage with residue

high net ecosystem production (NEP) and net carbon sequestration. Reducing tillage intensity with residue retention is more effective than zero tillage for balancing carbon emissions and increasing net carbon sinks in coastal lowland rice systems.

Rapid acidulated manure (RAM) for restoring the health of alkaline soil: Acidification of farmyard manure and city waste compost by the addition of elemental S (S°) and S°–oxidizers is an easy and simple way to increase the reclamation potential because chemical and microbiological conversion of S° produces mineral acids that cause rapid acidulation. Application of 20 kg S° for each tonne of farmyard manure and city waste compost generates an appreciable quantity of titratable acidity (TA) of 5,984 and 726 me/kg, respectively, after 28 days of incubation. Acidulated manure and city waste compost termed Rapid Acidulated Manure (RAM) dissolve inherent soil $CaCO_3$ and reduce pH because it has the potential for the production of equivalent alkaline as its neutralization potential (ENP) 6,366 and 912 me/L. Application of rapid acidulated city waste compost decreased pH_s (8.43) of alkali soil (8.60) irrigated with different RSC water irrigation. Besides, the neutralization of soil pH, the recurring application of compost in *kharif* season in rice-wheat cropping system increased Walkley–Black organic C (3.60 g/kg soil) than unamended control (2.8 g/kg soil). Acidulated composts effectively neutralized the alkalinity of partially reclaimed soil in lysimeter and multi-location farmers participatory trials in alkaline soils, improved yield and yield attributing parameters of sorghum and mustard, and rice and wheat grain yield, and reduced the erucic acid percent of mustard. Application of acidulated manure and city waste compost decreased soil pH, lowered down sodium adsorption ratio, increased microbial biomass C, N, P, and S, and enhanced the activities of soil enzymes, dehydrogenase, and alkaline phosphatase except for aryl sulphatase.

Zero-tillage potato cultivation with paddy-straw mulching in coastal saline soils: In the Ganges Delta's coastal region, rice is the main crop during the wet (*kharif*) season, while most land remains fallow in the dry (*rabi*) season due to soil salinity and lack of irrigation water. Implementing a rice-potato cropping system with zero-tillage potato planting, paddy-straw mulching, and scientific nutrient management can enhance productivity. This practice yields higher tuber output (21.5–32.3 tonnes/ha) compared to conventional methods and saves about 200 mm of irrigation water. Zero tillage with paddy-straw mulching improves tuber quality in crude protein, fat, crude fiber, and carbohydrate content. It also reduces potato cultivation costs by 27% (US$ 1,211.6/ha) compared to traditional ridge planting (US$ 1,660.4/ha). This approach yields a net return of US$ 1,779/ha, whereas conventional methods yield US$ 590/ha. Furthermore, zero tillage with mulching decreases soil salinity (ECe) from 5 to 3 dS/m, conserves soil moisture (4.0–8.0%), improves soil bulk density from 1.49 to 1.44 Mg/m^3, and increases soil organic carbon from 0.39 to 0.44%. Therefore, zero-tillage potato cultivation during the *rabi* season can boost cropping intensity and farmer income in the salt-affected Ganges Delta.

Management options to control groundwater depletion under changing climate: Extensive use of groundwater in the rice-wheat cropping system has caused groundwater depletion at an alarming rate of 33.0–88.0 cm per year over the past 2–3 decades in Northwest India. Projected climate change is expected to further impact crop water demand, groundwater withdrawal, and replenishment. A modeling study was conducted to simulate the effects of climate change on groundwater resources under the current rice-wheat cropping system and with revised crop management strategies in North-west India. Advancing the wheat sowing date by 10 days from the current date of 15 November, while maintaining the rice sowing date of 15 June, could reduce groundwater decline by 3.1, 6.4, and 10.6 m by early, mid, and end-century scenarios compared to the current sowing dates (15 June-15 November). Replacing 20.0%, 30.0%, and 40.0% of the rice area with maize in the rice-wheat system could reduce the average groundwater decline by 6.80, 9.60, and 13.8 m, respectively, compared to a projected decline of 28.5 m by the end of the 21st century under the current sowing dates.

Zero-tillage potato with straw mulching conserves soil moisture and allows easy harvesting of potato

Conservation agriculture-based sustainable intensification for mitigating global warming potential: Intensive tillage practices in the rice-wheat



Sub-surface drip irrigation in maize (*left*); tomato (*centre*); and baby corn (*right*) crops

(RW) system of North-west India have damaged soil and environmental health, reduced productivity trends, and increased greenhouse gas emissions. A study compared traditional agriculture with conservation agriculture (CA) in rice, maize, and pulse (soybean and pigeonpea) systems for resilience, productivity, economics, and greenhouse gas emissions. Traditional rice systems emitted the most methane (2,299 kg CO_2 eq./ha), while CA-based maize systems had the lowest (263 kg CO_2 eq./ha). Traditional rice systems also had the highest global warming potential (GWP, 7,479 kg CO_2 eq./ha) and global warming potential intensity (GWPi, 0.62 CO_2 eq./Mg). Rice systems had 47.0–51.0% higher total GWP and GWPi than CA-based maize and pulse systems. The main contributors to GWP were CH_4 and N_2O emissions from soil and energy use in irrigation, fertilization, and pesticides. CA-based systems improved productivity and farmers' profits. Specifically, CA-based maize systems showed significant improvements, including a 20.7% increase in system yield, a 42.2% rise in economic yield, a 138% boost in soil quality index (SQI), a 55.6% reduction in GWP, and a 43.5% increase in soil carbon stock compared to traditional rice systems.

Enhancing water productivity of maize-based cropping system under sub-surface drip irrigation: The performance of the sub-surface drip irrigation (SSDI) system at different lateral pressures (75 kPa, 100 kPa, 125 kPa and 150 kPa) and depths (10, 15, and 20 cm) was evaluated in maize-based cropping sequence (i.e. maize-tomato-baby corn). Response of the crops, viz. maize, tomato and baby corn about yield, water use, and water productivity (WP) under SSDI was also compared with those under surface drip irrigation (SDI) and surface irrigation (SI). Maize (sweet corn cv. Sugar 75) was grown during the *kharif* season (July-October), whereas tomato (cv. Arka Samrat) and baby corn (cv. G 5414) were grown during *rabi* (November-February) and summer (March-May) seasons, respectively. It was observed that there was a saving of 11.0% in irrigation water with a 6.00% higher yield, leading to 19.0% higher water productivity in SSDI (at 125 kPa with 15 cm depth) compared to SI (irrigation water, 210 mm; yield, 12.35 tonnes/ha; WP, 1.87 kg/m^3) in sweet corn during the *kharif* season. However, the yield and water use under SSDI were statistically at par ($P>0.05$) with that under SDI in sweet corn. In tomato crop, the SSDI operated at 125 kPa pressure with a lateral depth of 15 cm saved 18.0% and 38.0% irrigation water compared with SDI and SI (420 mm), respectively, during the *rabi* season. Moreover, the yield of tomato under SSDI (50.11 tonnes/ha) was 15.0% and 33.0% higher than SDI and SI, respectively. Higher yield with less water-use resulted in a 34.0% and 103% increase in WP under SSDI compared with SDI and SI, respectively, in tomato.

Similarly, in baby corn, SSDI saved 19.0% and 44.0% of irrigation water, and improved yield by 12.0% and 34.0%, compared to SDI and SI (water use, 360 mm; yield, 1.58 h/ha), respectively. The WP under SSDI (0.97 kg/m^3) was 33% and 126% higher than that under SDI and SI, respectively, in baby corn. The highest annual net return (₹5,68,371/ha) and benefit-cost ratio (3.57) were generated under SSDI, followed by SDI (net return, ₹4,92,490/ha; B:C ratio, 3.27) and SI (net return, ₹3,98,047/ha; B:C ratio, 2.69) in maize-tomato-baby corn cropping sequence.

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Conservation agriculture-based scenarios

9.

Mechanization and Energy Management

A variety of sensor-based, robotic and mechanical tools were developed to enhance agricultural operations at variuos stages. These include an image-based nitrogen applicator that adjusts fertilizer based on crop stress, and a multi-purpose unmanned vehicle for planting and weeding on small farms. Other innovations include a sensor-based fertilizer applicator for grape vineyards, a microcontroller-based poultry feed dispenser, and a radio frequency-controlled pesticide applicator. Additionally, a device for real-time detection of Groundnut Bud Necrosis Virus (Gbnv) using machine learning has been created for rapid disease severity estimation. A robotic metering system for vegetable transplanting and a Variable Rate Technology (VRT) robot for precise fertilizer application have also been designed, improving efficiency and reducing labour costs in farming. In field operations, innovations like the tractor-drawn eight-row onion transplanter, mechatronic planters for intercropping, and tractor-operated leaf detrashers for sugarcane have been introduced to increase efficiency. Other machines, such as a multi-utility e-vehicle for paddy harvesting and the turmeric combine harvester, help reduce manual labour. Additionally, tools like a tractor-operated trash mulcher for sugarcane ratoon crops and a six-row liquid urea injection machine have been developed to optimize resource usage and improve productivity across agricultural sectors. Post-harvest tools have been developed to enhance efficiency such as the electric motor-powered linseed thresher, offering 99% threshing efficiency and a bullock-powered linseed thresher with 96% efficiency for small-scale operations. A flax fibre extractor achieves over 90% efficiency in extracting fibre from retted flax straw. A power-operated jute ribboner, with a capacity of 4,000-5,000 plants per hour, increases fibre yield. In tobacco farming, solar thermal energy has been integrated into post-harvest curing processes, reducing wood fuel usage by up to 54%. A forage seed coating machine applies chemicals with 97% efficiency, reducing labour by 90%. In fish management, the diesel outboard motor offers 30% fuel savings, while a solar-powered fish feed dispenser utilizes IoT technology. The CIFT-MPEDA-Turtle Exclude Device (TED) reduces bycatch in trawl nets. A automated hybrid solar dryer dries fish efficiently, and a live fish transportation system ensures safe transport from farms to markets.

Sensor-Based and Robotic Tools for Agricultural Operations

Image-based variable-rate nitrogen applicator: An image-based variable-rate nitrogen applicator was developed to apply liquid nano-nitrogen fertilizer on rice and wheat crops. The applicator adjusts the fertilizer rate based on crop requirements, using real-time images to assess crop stress. A microcontroller activates the proportional control valve via a Sabertooth DC-powered driver, regulating fertilizer flow. Python 3 code, developed on Thonny software using a Raspberry Pi 4, operates the control valve. The system adjusts the liquid fertilizer rate according to nitrogen stress levels, and four hollow cone nozzles ensure uniform spraying over a 1.2 m width at a speed of 1.8 km/h. The applicator was tested on paddy and wheat crops, achieving over 70% accuracy in stress identification for foliar application of liquid fertilizer.

Unmanned multi-purpose track-type vehicle: An unmanned multi-purpose track-type vehicle was developed for use in small farms and hilly areas, featuring an 8.9 kW petrol engine. The vehicle is operated via a remote-control system that manages direction, speed, braking, and equipment functions during agricultural tasks. Attachments developed for the vehicle include a multi-row planter and a rotary weeder. The system demonstrated a field capacity of 0.16 ha/h and a field efficiency of 78% during carrot planting. The rotary weeder attachment was tested in sugarcane fields, achieving a field efficiency of 76%, weeding efficiency of 91%, and minimal plant damage of just 1.2%.

Sensor-based spot fertilizer applicator for grape vineyard: A machine has been developed for the precise application of granular fertilizer in grape vineyards. The applicator consists of four main components: a fertilizer metering system, furrow openers, a sensing unit, and a fertilizer dispensing unit. It delivers 84 g of SSP per plant, based on an application rate of 1,500 kg SSP/ha. Field tests were conducted in a grape vineyard with plants spaced at 2.70 m×1.80 m, covering an area of 0.5 ha. The applicator demonstrated an effective field capacity of 0.72 ha/h and a field efficiency of 77.6%. The prototype applicator is priced at ₹60,000, with an operating cost of ₹2,600/ha.

Micro-controller based automatic poultry feed dispenser: Poultry rearing involves unhygienic work and spreads infectious diseases from birds to humans and vice-versa. An automatic dispenser was developed for unmanned poultry feeding. The developed dispenser is equipped with a stepper motor driven by micro-controller. The capacity of the feed hopper is 62 kg. Four rollers are provided for easy movement. The capital cost and the operating cost of the machine per 100 feed are ₹50,000 and ₹2.30, respectively. The machine can achieve 65-70% saving in time and cost of feeding as compared to the manual circular feeding.

Radio frequency controlled pesticide applicator: A radio frequency (RF) controlled pesticide applicator was developed, comprising four main components: an RF module, a sprayer module (including a 19 L/min pump, spray boom, nozzle, and chemical tank), a driver module, and a trolley with wheels. The machine is powered by 24 V DC motors. The RF module ensures reliable long-distance communication. In field trials, the applicator covered 0.5 ha/h with a 2.65 m boom and 12 nozzles, achieving 65-70% efficiency at a forward speed of 3 km/h. However, uneven terrain impacted the speed.

Sensor based device for real time detection and severity estimation of Groundnut Bud Necrosis Virus (GBNV): A machine learning-based approach was used to develop a device for detecting and estimating GBNV severity in tomato and cowpea. The machine learning model categorizes disease severity into five classes: 0%, 1-10%, 11-25%, 26-50%, and >50%. Based on the decision tree model's accuracy, a spectral sensor-based device was created for disease detection and severity estimation. The device's outer casing was 3D printed using polylactic acid (PLA), and it integrates a spectral sensor (AS7341) for capturing data, an OLED display (SSD 1306) to show severity classes, and a Raspberry Pi 3B microprocessor (BCM2837 64bit) to run the classifier and process the data. Powered by a 10,000 mAh MI Li-Polymer battery, the device collects real-time spectral data, processes it rapidly with a 1.2 GHz processor, and provides immediate results. Unlike traditional methods that require manual sampling and lab analysis, this device enables real-time disease detection and intervention, significantly reducing time.

Robotic metering mechanism for vegetable transplanter using portray seedlings: A robotic metering mechanism for vegetable transplanter using portray seedlings was developed. The developed system comprises a robotic arm with 5 degrees of freedom (DOF), including the actuator, microcontroller, servo motor driver, rotary encoder, and battery. The performance of the developed robotic metering system was evaluated in the laboratory under simulated conditions. The test was conducted on a specially developed test bench. The robotic metering system achieved a maximum forward speed of 1 km/h for a plant-to-plant spacing of 40 cm. The performance of the robotic arm was assessed based on picking efficiency, seedling damage, and root-media adhesion under laboratory conditions. Optimum performance was observed at a machine forward speed of 0.7 km/h and a seedling age of 6 weeks, resulting in a picking efficiency of 99.6%, seedling damage of 4.0%, and root-media adhesion of 90.9%.

VRT robot for fertilizer application: A variable rate technology (VRT) robot was developed for precise fertilizer application across different crops throughout their growth cycle. With a ground clearance of 1.2 m, the robot is suitable for high-standing crops like pigeon pea. Its fertilizer discharge rate is synchronized with the robot's forward speed using rotary encoders. The VRT robot consists of a top cover, camera boxes (front and back), lifting mechanism, hitch bar, furrow openers, crop deflector, LED indicator with buzzer, fertilizer application rate actuator, delivery pipe, caster wheels, display screen, battery, controller, motor driver, driver wheels, two 350 W DC motors (24

Volt), gearbox, fertilizer box, servomotor (for adjusting the slotted roller), and DC motors for shaft rotation. The gearbox offers five speed settings, with speeds ranging from 0.38 km/h in 1st gear to 0.98 km/h in 5th gear. The robot's field capacity ranges from 0.56 ha/day to 1.39 ha/day, and it has a total carrying capacity of approximately 450 kg.

Machines and Tools for Field Operations

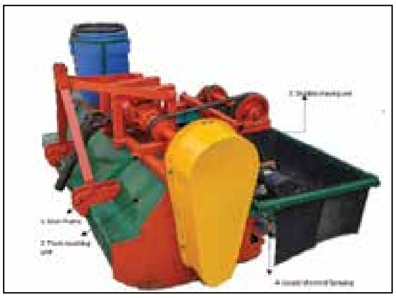
Tractor-drawn eight-row transplanter for onion seedlings: A tractor-drawn eight-row automatic transplanter was developed for transplanting onion seedlings in dry, well-prepared, and moderately leveled fields. The transplanter plants eight rows simultaneously with a 150 mm row spacing. Its seedling metering mechanism singulates seedlings at an average rate of 60 per min per row, releasing them in an upright orientation into the furrow. The machine is designed for transplanting 45-60 days old washed root onion seedlings with a neck diameter of 4-8 mm. The transplanting depth can be adjusted using gauge wheel-cum-transport wheels. Test results showed uniform plant spacing of 100±11 mm, with 78% singles, 9% doubles, 12% misses, and no damage. The transplanter operates with 75% efficiency at a speed of 0.6 km/h, covering a 2 m swath (1.2±0.8 m between beds), with an effective field capacity of 0.11 ha/h.

Mechatronic-driven planter suitable for intercropping: A five-row unit of the mechatronic-driven planter suitable for inter-cropping was developed to facilitate intercropping by simultaneous metering and sowing a wide range of crops with seed size ranging from 2 to 16 mm and seed-to-seed spacing from 100 to 600 mm. It can sense the forward speed of the planter in real-time and automatically adjust the rotational speed of metering cells to maintain the desired pre-set seed-to-seed spacing. It is suitable for simultaneous sowing of any three combinations of crops having different seed sizes such as castor with greengram, castor with cowpea, and pigeon pea with greengram, etc. as inter-crop.The field trials were conducted for sowing of castor with greengram, castor with cow-pea, and pigeonpea with greengram as inter-crop. The missing hills were found between 1.57-4.0%.

Tractor-operated sugarcane leaf detrasher-cum-shredder: Sugarcane leaf removal is very labour-intensive and time-consuming operation. About 300 man-hours per ha are required for leaf removal and harvesting of sugarcane crop. Standing sugarcane crop without leaves is also pre-requisite for operating sugarcane harvesters. Conventional hand-based detrashing poses significant health risks to workers, and manual leaf detrashing often results in improper removal of leaves. In order to mechanize sugarcane leaf detrashing-cum-shredding operation, tractor operated sugarcane leaf detrasher-cum-shredder was developed at MPKV, Rahuri centre of AICRP on FIM. The developed equipment was evaluated at Karveer, district Kolhapur in 13.09 ha area for 42 h. The effective field capacity of the machine was 0.31 ha/h and field efficiency was 82%. The net savings by using this machine amounted to ₹9,300/ha, i.e. 83.70% over conventional method.

Small tractor-operated adjustable sugarcane detrasher: Detrashing of sugarcane crop is a tedious, as well as time consuming operation. Buds are damaged due to the fixed detrashing rollers and trashes frequently get entangled on the roller units due to the uni-directional rotation of rollers. The bi-directional rotation of roller and adjustable movement has been provided in the developed prototype to reduce the damage during the operation. During field trials, roller speed of 8 m/s and height of 600 mm from ground level were ideal for detrashing of 1.50 m erected cane. The field capacity of the machine was 0.3-0.4 ha/h with 87% detrashing efficiency. The operational cost was ₹2,500/ha, resulting in a 66% cost saving.

Tractor-operated trash mulcher-cum-stubble shaver device for sugarcane ratoon crop (Patent No.: 526527): A tractor-operated trash mulcher-cum-stubble shaver for sugarcane ratoon crops was developed at ICAR-IISR, Lucknow, to manage sugarcane residue in manually harvested fields. Powered by a 45 hp tractor, the device draws rotary power from the PTO and includes three main units: trash mulching, liquid decomposer/chemical spraying, and stubble shaving. The trash mulching unit features differential height cutting blades that effectively shred and mulch trash from both the ridges and furrows of sugarcane rows. The liquid decomposer is sprayed over the shredded trash by a battery-powered spraying unit, followed by stubble shaving. The stubble shaving unit consists of two concave



discs with replaceable serrated blades that precisely shave stubbles from two rows without clogging. This ensures healthy and synchronous sprouting of cane buds beneath the soil surface. The device provides uniform trash shredding and spreading. It operates at a speed of 2.5 km/h, consuming 4.5 l/h of diesel with an effective field capacity of 0.3 ha/h and a field efficiency of 80%. This cost-effective machine reduces labour dependency and trash removal costs by 65% compared to manual methods, while improving ratoon crop initiation.

Tractor-operated brush-type cotton harvester: The low-cost indigenous brush and rubber bat-type cotton stripper was designed and developed to strip the cotton from open cotton bolls. It consists of a pair of counter-rotating rollers with three brush strips and three rubber bats. A centrifugal blower is used to convey the seed cotton from the delivery ends of both screw augers to a storage tank through an air duct. The machine has an effective field capacity of 0.1 ha/h, with a field efficiency of 80%, at a forward speed of 1.35 km/h. Its picking efficiency is 89.8% with a trash content of 29%.

High-clearance vehicle for unmanned tea leaf harvesting: An indigenous, self-propelled, hydraulically actuated high-clearance vehicle was developed to carry out tea-leaf plucking and pruning operations. Its components include a hydraulically driven transmission, cooling system, differential, and a disc-type negative brake system. It features 1.4 m of ground clearance and a track width that can be adjusted between 1.4 and 2 m. The maximum designed on-road speed of operation was 20 km/h, with a turning radius of 4 m. The vehicle's performance was found to be satisfactory at the tea garden of TTRI, Jorhat. *Source:* ICAR-CIAE, Bhopal.

Multi-utility e-vehicle with arrangement of reaper for harvesting: A multi-utility e-vehicle powered by $LiFePO_4$ battery (60V, 100 Ah) and BLDC motor (6 kW, 60V) along with controller was developed and tested with reaper for harvesting of paddy. A 12 V DC power pack was used for lifting and lowering the reaper assembly during operation in the field. The actual field capacity was 0.185 ha/h with field efficiency of 80% at forward speed of operation in the range of 2-3 km/h. Average current and power consumption during harvesting operation with e-vehicle was 37.53 A and 2.42 kW, respectively. Total energy consumption for harvesting operation was observed to be 6.90 MJ/ha.

Coulter-based six-row tractor-operated liquid urea injection machine: Foliar application of liquid nitrogen may cause evaporation loss. Application of liquid nitrogen in sub-soil is suggested to improve nutrient-use efficiency. This machine was developed for the application of liquid nitrogen in sub-soil. Copper capillary tubes are attached with straight tynes on a spring-loaded coulter assembly for liquid urea injection into sub-soil. The actual field capacity of the machine is 0.15 ha/h. At par wheat yield was recorded at 75% of recommended urea dose applied using the machine.

Hand-compactor for oyster mushroom production: The hand compression of paddy straw-spawn mixture is the most labour-intensive, time-consuming, tiresome operation in oyster mushroom production. A hand-compactor suitable for local conditions was developed for filling and compacting straw-spawn mixture. The mushroom bags were filled layer by layer and after each layer, spawn were spread evenly over the straw. Mixture was then compacted at a pressure of 22 kg by holding for 3-5 s and the ram was returned to its starting position. The compacted straw-spawn mixture in the bag was then removed, tightly sealed, and placed in the cropping room under a rack system for the spawn run. The weight of the bags ranged from 2.8 to 3.5 kg.

Tractor-operated turmeric combine: Harvesting is a labour-intensive process in turmeric cultivation, as it requires around 150 man/h of labourers to harvest 1 ha of a turmeric field. A tractor-operated turmeric combine harvester was developed. It consists of a de-topping unit, a digger-cum-conveyor unit, and a collection tank. The digging width is 750 mm, and the rhizome-conveying speed is set at 250 rpm. The total power requirement for operation equipment is 28 kW, so a tractor having 35-40 kW is sufficient to operate the equipment. The field capacity was observed as 0.16 ha/h with 97% digging efficiency, 94% de-topping efficiency and 70% cleaning efficiency at a forward speed of 2.5 km/h. The cost of operation was ₹1,100/h.

Technology for direct sowing of rice seed pellet: The technology of preparing and sowing of the rice seed pellet was developed for proper germination. The binding materials such as organic manure and bentonite clay were used for making seed pellet. Field trials of multiple rice seed pellets in puddled soil using a manual planter showed an average hill spacing of 174.2 mm, hill population of 3 and hill spacing uniformity of 80.22%, as against 98.1 mm hill spacing, 6.1 hill population, and 63.63% hill spacing uniformity, respectively in case of direct seeding by drum seeder. The performance of sowing seed pellets using planters was better in terms of reduced seed scattering, better plant stand, and more uniform hill spacing as compared to the manual drum seeder.

Tractor-operated lathyrus harvester: The grass pea (*Lathyrus sativus*), also known as khesari, is a food and fodder crop from the legume family. Traditionally, it is harvested manually which is labor-intensive and time-consuming. A tractor-operated lathyrus harvester was developed, consisting of a cutting unit, reel unit, gathering unit, and crop cleaner mechanism. Key performance results of the harvester include a field capacity of 0.42 ha/h, field efficiency of 85%, harvesting efficiency of 90%, and 3.50% losses (including cutter bar, conveying, and shattering losses). The machine costs ₹1,45,000, with ₹789/h or ₹1878/ha operational cost. The harvester provides about 75% cost savings over traditional methods.

Linear move irrigation system: An indigenous linear move irrigation system suitable for small farms was developed using a guiding arrangement. It is suitable for crop height up to 1.5 m. The developed system takes about 12 h to irrigate 0.4 ha area with a 50 mm irrigation depth. Using timer controllers and single- and three-phase electric circuits, the developed system moves at a forward speed of 0.2 km/h and operates semi-automatically to apply the scheduled depth of irrigation on a stop-and-go mode as per the pre-set duration. The cost of the developed system is approximately ₹1,00,000. It has distribution uniformity of 78.5% and 86.2% coefficient of uniformity.

Development of tractor-drawn multi-crop seed drill for small seeded crops: The tractor-drawn multi-crop seed drill is designed for precision sowing of jute and other small-seeded crops. It uses an inclined plate metering mechanism to accurately place seeds in rows. Driven by a tractor (35 hp and above) through a 3-point linkage, the machine includes a separate box and metering system for granular fertilizer application. Power is transmitted from the ground wheel to the metering mechanism via chain, sprocket, and bevel gear drive. The drill has 7 rows with a 25 cm spacing, adjustable for different crops. The seed box ensures controlled seed addition to the metering unit, while an outlet at the box's bottom removes unused seeds. A rear platform allows the operator to inspect and regulate seed quantity. Compared to manual drills, it reduces seed rate by 50% (3.0-3.5 kg/ha vs. 7-8 kg/ha for broadcast sowing) and labour by up to 60%, saving ₹ 6,500–11,500 per ha in weeding costs. It can also sow other small-seeded crops like millets, mustard, and sesame.

Rotary disc drill: This rotary disc drill (RDD) machine is capable of direct seeding the crop under full crop residue of either rice or sugarcane and Patent#469755 was granted for its commercialization. Direct seeding using RDD helps in advancing the sowing time, increasing cropping intensity in sugarcane cropping system and saving about ₹3,500/ha on elimination of preparatory tillage. Field demonstrations were conducted at farmers' fields for *in-situ* management of crop residue in rice-wheat and sugarcane-wheat cropping systems using RDD in Karnal district of Haryana.

Small tractor operated EPN applicator for sugarcane white grub management: A mini tractor operated EPN applicator has been developed jointly by ICAR-CIAE, Regional Centre, Coimbatore and ICAR-SBI, Coimbatore, for effective dispensing of entomopathogenic nematode, a biocontrol agent to control white grub, *Holotrichia serrata* in sugarcane. The cost of operation was worked out as ₹2,550 per ha and cost saving is 47% when compare to manual method of application. The technology has been commercialized to M/s Greenfield Equipment India Pvt Ltd, Coimbatore for commercial production.

Manual multicrop planter: A manual multicrop planter was developed for sowing vegetable seeds in small fields, experimental plots, greenhouses, and nurseries. The planter features a 2-3 kg seed hopper, making it ideal for small-scale operations. Its seed metering unit uses interchangeable plates for planting various crops and includes a cleaning mechanism and seed knocking system for smooth seed flow. The planter offers an adjustable sowing depth of up to 8 cm, ensuring flexibility for different crops. A drive and press roller ensure uniform seed placement and soil coverage. The long, adjustable handle provides ergonomic use, reducing user fatigue. Additionally, the seed metering unit offers three adjustable speeds, allowing control over sowing rate based on field conditions and crop needs. This versatile planter is perfect for efficient vegetable production in small or controlled environments.

IIPR-Roller contact type herbicide applicator: Herbicide application is crucial for weed control in pulse crop production, as weeds can reduce yields by about 37%. To apply systemic and non-selective herbicides effectively, proper applicators are needed. A herbicide applicator has been developed for crops with a row spacing of 30 cm. The applicator, with dimensions 105 ×54 ×111 cm, includes a 4-l water tank, a 24 cm roller (diameter 5.8 cm), and a delivery pipe (1-inch diameter) with valve and orifice-type nozzles. The discharge rate of the applicator at various valve openings (6.25%, 12.5%, 25%, 50%, and 100%) ranges from 0.61±0.01 to 5.29±0.02 L min. The roller wetting capacity is 0.205±0.002 m²/s. The applicator's field capacity is 0.05-0.07 ha/h, and it can also be used on field bunds to control weeds. With a weeding efficiency of 80-85%, the equipment is gender-friendly and can be operated by women farmers.

IIPR-Manual weeder: Weeding is one of the important operations in crop production systems. The average yield reduction due to weeds is about 37%. Keeping this in mind, the ICAR-IIPR, Kanpur, has developed a mechanical manual weeder. The manual wheel-hoe weeder has a multi-tool bar carrier for multiple attachments of blades of different sizes and shapes to cater needs of the weeding at different stages and types of the pulses crop. For row-to-row spacings of 30 cm the blade of size 18 cm was fabricated, whereas for the row-to-row spacings of 25 and 22.5 cm, blade size of 12.5 cm has been fabricated. The weeder has been tested for weeding in the lentil and chickpea and showed a field capacity of 0.02-0.03 ha/h with a weeding efficiency of 90% and a draft requirement of 31 N. It is gender friendly and can be operated by even a single woman worker. *Source:* ICAR-IIPR, Kanpur.

Post-Harvest Tools and Machines

Electric motor-powered head feed linseed threshers: The conventional method of threshing linseed involves significant manual labour, making it

Modular water harvesting structure using plastic waste

A modular water harvesting structure utilizing HDPE plastic waste technology was developed. The HDPE plastic waste is integral to the water harvesting system. The structure successfully harvested around 700 m³ of rainwater, which was recharged five times during the season, resulting in a total recharge of 3,500 m³. Economic analysis indicates that the cost of constructing this water harvesting structure with modular plastic blocks is about ₹1.1 lakh, compared to ₹1.4 lakh for a structure built with UCR masonry. Additionally, using modular plastic blocks significantly reduces carbon emissions by 87%. The total estimated carbon emission from the construction of this water harvesting structure is 167.15 kg CO_2 equivalent per year.

a time-consuming and arduous task for farmers. To address this issue, a head feed type linseed thresher was developed. This prototype operating as a "hold on" type was designed to not only separate linseeds, but also preserve the stalks for potential fibre extraction. This thresher is operated by 0.375 kW electric motor and is useful for small farmers. The threshing capacity of the prototype is 178 kg/h with 99% efficiency. The cost of machine is ₹50,000 with an operating cost of ₹90/h. The machine offers an output 17.8 times more than the traditional method.

Bullock-powered linseed thresher: A bullock-operated linseed thresher was developed by the OUAT Centre of AICRP on UAE. It has an average output capacity of 23 kg/h and a threshing efficiency of 96%, which improves with higher moisture content of the ear heads and greater concave clearance. The average cleaning efficiency is 95%, although it decreases as concave clearance increases. The average grain breakage percentage is 0.7%.

Improved fibre extractor for flax (*Linum usitatissimum*): The improved flax fibre extractor is designed for high-capacity extraction from retted and dried flax straws. Powered by a 5 hp three-phase electric motor, the machine features longitudinal grooved nylon rollers driven by a chain, sprockets, and pinions. The rollers are mounted on two side plates and arranged with minimal clearance, forming seven scutching points for optimal fibre extraction. Flax straw is fed horizontally through these points for efficient scutching. A conveyor belt at the inlet ensures continuous feeding of straw. The machine requires two operators: one for feeding and another for collecting the scutched fibre. With a material capacity of 75-80 kg of flax straw per h and a throughput capacity of 40-45 kg of fibre per h, the extractor achieves a fibre extraction efficiency of over 90%, with minimal loss. The machine can deal with 450–480 kg of retted and dried straw in a day and produce 210–225 kg of fibre. The machine can extract fibre from the flax straw of 1 ha area in 7-8 days. The flax fibre extraction using the machine reduces drudgery and as requirements to 12–14 man-days/ha.

Development of jute ribboner: The power-operated jute ribboner is designed to extract jute ribbons from freshly harvested plants without damaging the sticks. Powered by a 3 hp single-phase electric motor or a 5 hp diesel engine with minor modifications, it features two sets of stick breaker-cum-ribbon pulling units stacked one above the other. The machine has two input chutes, enabling two operators to work simultaneously. Each breaker unit processes 5-6 jute plants, handling 10-12 plants at a time. The process involves feeding the jute plants by the butt end into the upper breaking rollers, which crush the sticks to about 5 cm. The lower rollers then pull the ribbons at high speed, placing them on a conveyor belt for delivery. The sticks are ejected intact. With a processing capacity of 4,000-5,000 plants per h and fibre extraction efficiency exceeding 90%, the ribbon retting process boosts fibre yield from 5-6% to 7-8% compared to traditional whole-plant retting.

Alternate source of energy for post-harvest curing of flue-cured tobacco green leaf : Post-harvest curing of flue-cured tobacco green leaf is a crucial operation performed in specialized structures called barns, where temperature and relative humidity are carefully controlled. Wood is the primary energy source for fueling the flue-curing barns, with a consumption rate of 5 kg of wood per kg of cured leaf. To reduce reliance on wood fuel, the use of solar thermal energy and other alternative energy sources has been explored. Solar energy interventions, including polycarbonate roof chambers, hot air circulation, and hot water circulation, have reduced wood consumption by approximately 33%. When integrated with biomass energy, electrical energy, or gas, these interventions have the potential to reduce wood fuel usage by up to 54%.

Poly carbonate roof chamber

Solar hot water equipment

Forage seed coating machine: A seed coating machine has been developed to apply polymer-based chemical agents in a thin layer on the surface of forage seeds, effectively disinfecting them from seed-borne or soil-borne pathogens and storage insects. The machine has a coating capacity of 6 q/h for berseem seeds and 6.5 q/h for cowpea seeds, with an efficiency of approximately 97%. In contrast to manual coating, which is labour-intensive, requires more chemicals, and results in uneven application (taking one hour to coat 50-60 kg of seeds), the developed machine ensures precise chemical

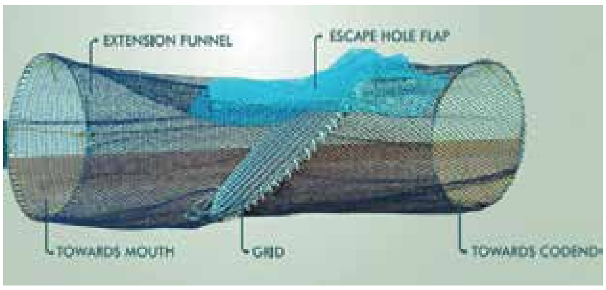
layering, reducing labour by 90%.

Machines and Tools for Fish Mangement

Diesel out board motor for fishing boat propulsion: ICAR-CIFT designed and fabricated a diesel engine driven out board motor (OBM) of 58 hp to resolve the petrol plus kerosene crisis in the fishing industry, with approximate savings of 30%. The technology has been transferred to Department of Fisheries, Government of Kerala.

Solar-powered automatic fish feed dispenser: A solar-powered automatic fish feed dispenser was fabricated using a single-board microcontroller which dispenses a pre-determined amount of feed at set time intervals. The unit consists of a solar panel, feed hopper, feed dispensing rotating plate, DC motor, battery, charge controller, keypad, Real Time Clock module, LCD and high-density polyethene (HDPE) aqua float. To operate the unit under an automatic mechanism, a propeller has been fixed to the system. The system was built on the framework of the Internet of Things (IoT) with a Radiofrequency (RF) module included for wireless data transmission using a single-board microcontroller.

CIFT-MPEDA-TED: CIFT-MPEDA-Turtle Exclude Device (TED) is a bycatch reduction device fitted in trawl nets used for fishing to exclude turtles and large aquatic animals, which accidentally enter in the net, within 2-3 min. The device has been developed as per International standards and consists of oval



Live fish transportation system

The live fish transportation system has an insulated HDPE box with stainless steel fish holding chamber and jacketed cooling system. It has provision for aeration using oxygen cylinder and diffusers from the bottom of the container. The system serves the purpose of transportation of live fishes of table-size from farm to the market.

aluminium alloy frame with bar space fixed in the trawl belly between 50-55^{o} angle with an opening at the top.

Automated hybrid solar dryer: Automated hybrid solar dryer has a flat-plate solar water collector as the

Automated hybrid solar dryer

main source of heat energy and an LPG water heater as a backup heat source for continuous drying operations even under unfavourable weather conditions, such as during night and cloudy/rainy days. This dryer uses water as energy storage and heat transfer medium, and air as an intermediate medium for drying. The system has manual sun-tracking mechanism for harnessing maximum solar energy during sunshine hours. It has provision of dehumidifier, if operated under high humidity conditions. Its capacity is 60 kg with total tray area of 22 m^2. With the help of sensors and a PLC system, the total drying process is automated.

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Post-harvest Management and Value-addition

Various innovative technologies have been developed for improving food security, sustainability, and workplace safety, with a strong focus on reducing environmental harm and fostering innovation. One such advancement is the Visible Light Insect Trap, designed to attract and trap insect pests that damage stored grains. Unlike traditional UV-based traps, this design is safer, uses energy-efficient LEDs, and achieves an impressive attraction efficiency of 65-93%, effectively managing beetle and moth pests without harming the environment. In food production, the Table-top Vacuum Fryer offers a compact solution for frying foods at lower temperatures under vacuum conditions, preserving nutrients and colour while reducing harmful compounds like acrylamide. This energy-efficient technology is ideal for small-scale food production, enhancing both nutritional value and food safety. Another notable food innovation is Makhana Puffs, which uses by-products from makhana and other grains to create a nutritious, protein-rich snack, perfect for children's diets. Sustainability is further promoted with the development of Mycelium-Based Packaging, which converts agricultural residues like rice and wheat straw into biodegradable packaging. This eco-friendly alternative reduces reliance on non-recyclable materials like styrofoam, addressing environmental concerns. Additionally, the Multi-Crop Processing Machine helps small and medium-scale farmers process various crops efficiently, improving productivity and income while minimizing seed damage. For industrial applications, Industrial Cut-Resistant Gloves made from a multilayer fabric of cotton and Ultra-High Molecular Weight Polyethylene (UHMWPE) fibres provide lightweight yet durable protection, meeting high safety standards in industries like construction and metal handling. Another sustainable innovation is Sustainable Leather Products, made from agricultural by-products like cashew apple bagasse and arecanut fibre, offering a biodegradable alternative to traditional leather. In food processing, a standardized protocol for minimal processing of tender jackfruit was developed, using treatments like ozone, ascorbic acid, tartaric acid, and citric acid. Ascorbic acid treatment, when combined with polypropylene packaging and low-temperature storage, extended the shelf-life of jackfruit to 9 days, while ozone treatment improved firmness and increased phenolic content. Additionally, an edible coating for tomatoes using carboxymethyl cellulose (CMC) and lemongrass essential oil reduced physiological weight loss and extended the shelf-life by 15 days at room temperature. A HyperAfla instrument was also developed to rapidly detect aflatoxin in maize, an important food safety concern. This portable instrument provides quick results with over 81% accuracy, classifying grains into different levels of aflatoxin contamination. Other innovations aimed at improving food processing efficiency include the power-operated jackfruit cutting machine, which saves 70% of the time compared to manual cutting, and the peeling machine for tender jackfruit, which achieves 90-95% efficiency with minimal peel loss. The power-operated baby corn grader ensures accurate grading, while the grain handling and bagging system facilitates better storage and disinfestation during drying. Sustainability-driven innovations also include the solar-powered electric bhatta for button lac production, reducing dependence on wood, and the paddy straw-based insulating box for eco-friendly vegetable storage. The production of biodegradable films made from materials like PLA and corn starch with a commercial output of 240 tonnes annually, addresses plastic pollution.

Visible light insect trap: Various biotic and abiotic factors affect the quality of the food grains during storage. Among the biotic factors, insects cause major damage, contributing one third of the total storage losses. There are several management strategies in practice; however, the non-chemical ones are preferred. ICAR-CIPHET has developed a visible range light trap with efficient attraction capacity and no UV exposure hazards. The trap designed to effectively trap insects, regardless of the type of grain being stored. It is an effective trap for both beetle and moth pests' management, irrespective of the sex (male and female). It can efficiently capture insect species like *Rhyzopertha dominica,* *Lasioderma serricorne, Cadra cautella, Sitotroga cerealella, Tribolium castaneum*, and *Laemophloeus* spp. The attraction efficiency ranges from 65-93%, depending upon the insects, wherein highest attraction (93%) was reported in *Sitotroga cerealella.* The trap has an attraction range of 8 m distance (radius from front). Use of LED helps in reducing energy consumption.This trap aids in monitoring the infestation and managing insect pests.

Table-top vacuum fryer: The table-top vacuum fryer is a compact frying system with specific components designed for efficient operation. Its frying vessel, made from SS-304 stainless steel, has a volume of 0.049 m³, with an internal diameter of 360 mm and glass wool insulation. The control panel is equipped with a temperature controller and RTD temperature sensor. The system requires a minimum of 8-10 l of oil for operation and has overall dimensions of 1,200 mm × 465 mm × 985 mm (length × width × height). This vacuum fryer is designed for precise and controlled frying under vacuum conditions for frying foods at lower temperatures, preserving nutritional value and colour while reducing oil absorption. It also minimizes the formation of harmful compounds like acrylamide. The compact design makes it suitable for small-scale or experimental food production.

Biothermocol - Mycelium based packaging material from crop residue: With so many items being distributed in packaged form and our global population rising, the usage of polystyrene packing is increasing dramatically. Expanded polystyrene (EPS) or Styrofoam, is a petroleum-based non-recyclable and non-biodegradable foam. Production of polystyrene creates the worst impact on the environment, in terms of energy consumption and greenhouse gas emissions. After harvesting of various agricultural crops, a large quantity of residues; around 500 million tonnes are generated (both on and off farm). After being used in various applications such as cattle feed, animal bedding, cooking fuel, organic manure etc., about 234 million tonnes of residues generated in India is available as surplus every year and major portion of this is unused crops residues is burnt in the irrigated areas, where multiple crops are grown annually. Recently researcher have started focussing on an emerging green and sustainable class; mycelium-based packaging material as a substitute to polystyrene (EPS) or styrofoam to reduce unbearable environmental issues. Hence an attempt was made to convert agricultural residue into mycelium-based packaging material.

Agricultural residues (rice straw and wheat straw) obtained locally were processed for size reduction by chopping to obtain desired sizes. The substrate was sterilized in autoclave for required time and inoculated with spawn of desired mushroom. After incubating at desired temperature for 7 days the material was shattered, and then filled into the moulds, and incubated further for 6-7 days under the required conditions. After growth the material was dried at 65-75°C for 12-18 h. The products prepared using this technology are biobased, environmentally friendly, biodegradable, fire retardant and hydrophobic in nature, and an excellent replacement to styrofoam/thermocol.

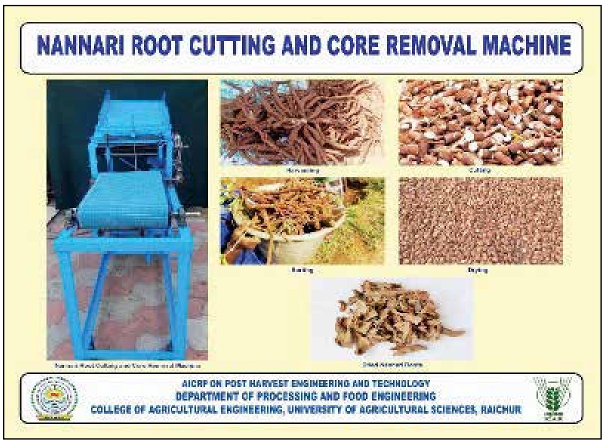
Multi-crop processing (5-in-1) machine: The multi-crop processing machine (5-in-1 machine) has been developed to process groundnut, sunflower, maize, and castor, thereby increasing the availability of raw materials for both domestic and export processing industries. This machine is particularly beneficial for small to medium-scale farmers, processors, startup entrepreneurs, seed processing industries, hotels, restaurants, and cottage industries, as it can help double their income. The 5-in-1 machine operates with a 0.5-1 HP single-phase electric motor. In one hour, it can separate 50 kg of pods from groundnut crops, extract seeds from 120 kg of groundnut pods with less than 2% breakage, process seeds from 250 ear heads of sunflower, and separate seeds from 250 maize cobs, all without any visual damage to the groundnut pods, maize seeds, and sunflower seeds. Additionally, it is capable of castor decortication with an efficiency of 99% and a capacity of 100 kg per h. The overall efficiency of the machine for all crops is 98%, and the germination rate of all seeds obtained from the machine exceeds 95%. The machine is compact, portable, and easy to operate, with a cost of ₹50,000. This price is 3-4 times less than the total cost of four separate machines required to process groundnut, sunflower, maize, and castor.

Grain amaranthus thresher: The grain amaranthus thresher consists of a threshing unit, sieve walker, blower, mainframe, shafts with bearings, a V-belt, and a pulley

for power transmission, all powered by a single-phase 2 HP electric motor. The overall dimensions of the thresher are 650 mm (length) × 1020 mm (width) × 1225 mm (height). The machine operates with a power requirement of 2 HP and has a processing capacity of 13 kg/h. The patent for this machine has been granted (No. 91530). Grain amaranthus cobs are fed through the feed hopper, where they enter the threshing drum and undergo the threshing operation. The threshed grains then pass through the oscillating sieve mechanism, where empty cobs are separated. Finally, the threshed grains are collected at the seed outlet of the thresher. The cost of the machine is ₹30,000.

Buckwheat-cum-sunflower dehuller: A buckwheat dehuller has been developed with a 1 HP single-phase motor and has overall dimensions of 82 cm (length) × 55 cm (width) × 116 cm (height), with an approximate weight of 82 kg. The main components of the machine include a hopper, a dehulling unit featuring a rough-surfaced dehulling drum with a perforated concave, a blower, and outlets. The machine has a processing capacity of 12-18 kg/h and achieves a dehulling efficiency of over 90%. It requires one person to operate and is priced at ₹ 40,000.

Nannari root slicer and core removal machine: The developed nannari root cutting and core separator unit consists of a hopper, rollers, a cutting blade, and a core separator. The machine is equipped with a 1 HP 3-phase motor and an attached differential gearbox (1:12), featuring a grooved pulley connected to the main shaft. Nannari roots are cut into 25 mm pieces by a sharp knife connected to an eccentric unit. The cut roots are then moved to the core separator unit, where a needle pushes the core of the nannari root using a reciprocating action. The separated core and roots are collected at the discharge outlet. The machine has a capacity of 50 kg/h, which can be scaled up to a higher capacity, and is priced at ₹ 1,50,000.

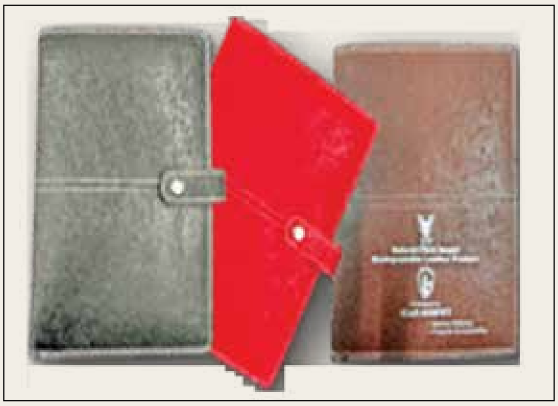


Process for preparation of 'Makhana puffs': Lower grade coproducts or by-products of makhana popping (unpopped/semi-popped/flattened popped makhana), maize, potato flour, dehulled blackgram dhal and rice were taken as ingredients for production of "Makhana Puffs". These ingredients were reduced in size by grinding and formulation was prepared. Moisture content of formulation was set to 15-16% and fed to extruder for puffing. The extruder parameters were 10.5 kg/h feed rate, 325 rpm screw speed, 60-80°C barrel temperature and 110 ± 2°C die head temperature. The puffs were dried to 3-4% moisture content (w.b.).

Success Story

Cashew Apple Bagasse and Arecanut Fibre-Based Leather Products

Cashew apple bagasse and arecanut fibre are by-product from their crops and remained unutilised for so long. ICAR-NINFET developed a technology to extract fibres from Cashew apple bagasse and arecanut fibre and utilised them as reinforcement in development of biodegradable engineered leather. Cost of developed leather-based product is lesser than natural leather. This flexible composite can be used to develop purse, wallet, life style items and footwear items. The technology is licensed to M/s Parna Creation Pvt. Ltd. of Shivamogga in Karnataka. Agri-entrepreneurship initiative of its CEO, Mr. S.R. Suresh, on production of various products using arecanut byproducts, was telecasted in the programme "Mann Ki Baat" of Hon'ble Prime Minister Mr. Narendra Modi on 25th December 2022. The firm standardized the vegan leather technology from areca fibre with the technical support of NINFET scientific team after signing a Memorandum of Understanding (MoU) through Agri-Innovate. The unit manufactures vegan leather from various natural fibres such as cotton, pineapple, viscose, sisal and arecanut etc., having a capacity of 1,000 square meters per month. Vegan leather technology is in good demand in India and abroad due to sustainable, cruelty free, pollution free and biodegradable leather products.



Makhana puffs are rich in protein, minerals, antioxidants and dietary fibre. This product may be useful for children who require nutritious and healthy foods for their growth and development.

Microbe mediated keratin extraction from animal hair: A keratinase positive bacterial strain, AR has been identified to solubilize keratin from coarse wool and hair under specified conditions. Bacterial culture grown with trimmed wool and incubated. Solubilized material is then centrifuged to remove undissolved material and bacterial cell debris. The clear supernatant is precipitated as keratin protein. The green method gives 56% solubilization of coarse sheep wool in comparison with conventional chemical method. The lyophilized protein can be used for cosmetic, medical and functional textiles applications.

Biodegradable sanitary products from natural fibre: Conventional sanitary napkins produce bulk non-degradable waste in India. Institute developed a biodegradable Sanitary Napkin as per BIS standard using a natural fibre as absorbent layer, bio-fabric as acquisition layer; Bioplastic as a barrier layer and hydrogel replacement for non-biodegradable super absorbent polymer (SAP).

Lac-based coating formulation for extending shelf-life of ginger: Lac-based coating formulation has been prepared for coating of ginger. Ginger once harvested loses moisture, weight loss, characteristics etc. very fast. Fresh ginger, after harvesting, has been thoroughly washed with water to remove all the impurities, followed by sterilization with 5% sodium hypochlorite solution for 5, 10 and 15 min. The treated ginger has been coated with lac-based coating formulation (5% and 10%) and stored at ambient (29-31°C, RH 65-72%) and 20° C (RH- 55%) for four months. The samples are drawn periodically (0, 50, 80 and 120 days) and studied for weight loss, number of sprouts/kg, sprouts growth (mm), shrivelling (%), penetration force, etc.

One-time pre-grooved chrome leather rollers for cotton ginning : ICAR-CIRCOT has developed novel One-time Equidistant Pre-grooved Chrome Leather Roller to eliminate the periodic re-grooving. The equidistant one time deep-grooved chrome leather roller of desired working depth have been formulated by using a specially developed deep groove forming automatic machine. The benefits of the technology are, improved working life of the roller, eliminates the down time due to frequent re-grooving of the rollers, about 2-3 bales more per shift from ginning factory of 48 DR gins, reduces drudgery of labour involved in re-grooving operation, prevents lint quality deterioration, no seed cuts in the lint due to uniform groove width and depth, no smoke pollution caused due to re-grooving operation. The technology has been commercialised to M/s Bajaj Steel Industries Limited.

Industrial cut-resistance glove using Multilayer Weaving Technique: Industrial cut-resistance glove using Multilayer Weaving Technique has been developed. Multilayer weaving, a technique to combine different materials, was used to produce a light weight cut-resistance glove without compromising its primary functions, such as protection, comfort, and mobility. Three layers of warps sheet were prepared from cotton in top and bottom layer and Ultra-High Molecular Weight

Polyethylene (UHMWPE) multifilament used in the middle. The UHMWPE has high toughness, high strength and low density and used as weft 156 per inch. The developed multilayer fabric which contains 78% of UHMWPE and 22% cotton was made into gloves and tested as per the EN 388 standards. The results showed that the glove passes level 3 cut resistance performance (7.34 blade cut index) with level 2 puncture resistance (76 N), level 5 tear strength (296 N). The potential of these gloves to revolutionize workplace safety and performance has a lasting impact on industries.The glove provides better protection, light weight, comfort and mobility. These gloves can find application in construction, glass or metal sheet handling, stamping/ hardware assembly/raw materials handling.

Lab gin: ICAR-CIRCOT, in collaboration with M/s. Precision Tooling Engineers, Nagpur, has developed a 700 mm roller length Single Roller Laboratory Model Gin (Lab Gin SR700) for quick measuring/evaluation of ginning percentage of raw cotton. The machine has the chrome-leather roller, knife, single piece sturdy heavy-duty vibration free broadsheet metal body along with seed collection tray and 2 HP 3 phase heavy duty electric motor. The length of roller is 700 mm, and diameter is 150 mm. This machine has capacity to process about 50 kg raw cotton per hour.

Extra long staple calibration cotton : The testing protocol for evaluating quality of extra-long staple (ELS) cotton is different from the short, medium and long staple cottons. A separate calibration cotton is required for testing ELS cotton and USDA is supplying PIMA calibration cotton for such purpose. However, there is no indigenously available ELS calibration cotton. ICAR-CIRCOT has developed indigenous ELS calibration cotton suitable for our cultivars.This ELS calibration cotton is expected to fuel the demand for indigenous calibration cotton in the ELS segment and can save valuable foreign exchange.

Air-purifying curtain : ICAR-CIRCOT developed an air-purifying curtain using activated charcoal embedded multilayer fabric for effective indoor air filtration. The developed product focus on indoor air purification and comprises integrated distinct fabric layers, each contributing unique functionalities aimed at optimizing air purification. The combination of cotton fabric with activated charcoal-treated polyester and cotton blend fabric resulted in a multilayer curtain capable of effectively filtering particulate matter and total volatile organic compounds (TVOCs) from indoor air. Comparative analysis with a market-available air-purifying curtain revealed comparable air permeability and filtration efficiency, indicating the potential of the developed curtain as a viable alternative for indoor air filtration. The multi-layered design, coupled with the incorporation of activated charcoal, offers advantages in terms of filtration efficiency and potential odour absorption, positioning the developed curtain as a promising solution for improving indoor air quality.

Protocol for minimal processing of fresh cut jackfruit: The process protocol has been standardized for the minimal processing of tender jackfruit. Total four treatments, viz. ozone (1 ppm), ascorbic acid (2.5%), tartaric acid (2.5%) and citric acid (2.5%) were given to the peeled and cut tender jackfruit slices. Treated samples were packed in two packaging materials,

viz. low-density polyethylene (LDPE, 100 µm) and polypropylene (PP, 40 µm). The samples were stored at ambient and low temperature (4-5°C) conditions. Quality analysis of the stored samples were carried out at an interval of two days for selected dependent variables. The cut tender jackfruit treated with ascorbic acid, stored in PP at low temperature, resulted in the highest storage life (09 days) as compared to other treatments. This ascorbic acid treated sample was having PLW of 0.31% at the end of storage life (09 days). Treatment of ozone resulted in maximum TPC of 76.472±0.07 mg/100 g and the highest retention of firmness (105.49±6.30 N) after 9 days of storage. The results revealed that post cut treatment of ozone (1 ppm for 10 min) and ascorbic acid (2.5%) retained the physico-chemical and textural qualities of tender jackfruit.

Process protocol for edible coating of tomato using dipping method: Carboxyl methyl cellulose (CMC) was used for the development of coating for fresh tomatoes to extend their shelf-life. The concentrations (1, 2, 3, 4%) of CMC based edible coating with 40% glycerol (dry weight of the starch) were applied on the surface of tomato and optimized based on the maximum reduction in physiological weight loss (PLW). Thereafter, the concentration (0.25%, 0.5% and 1%) of lemon grass essential oil (LEO) was optimized with 1% of mango kernel starch (MKS) based edible coating for tomato. The results showed that the edible coating for 1% MKS with 0.5% lemongrass essential oil with 40% (w/v) glycerol have shown the maximum reduction of PLW and total yeast and mold count. The effect of selected and optimized CMC based edible coating with essential oils was investigated on the post-harvest shelf-life of tomato at room (23±2ºC) temperature. The CMC based edible coating composite with lemon grass essential oils caused retarded loss in water, higher firmness, better colour attributes, visual appearance, anti-microbial and antioxidant activity of the fruits. The self-life of edible coating treated tomato was 15 days at room temperature.

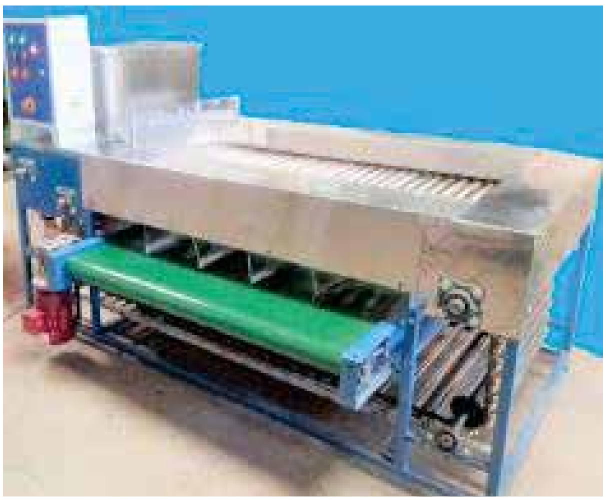
Days	Control	Coated
0		
3		
6		
9		
12		
15		
18		

Instrument for rapid detection of aflatoxin in maize—HyperAfla: A rapid detection instrument for Alfatoxin-B1 in maize has been developed. Exposure of maize to *Aspergillus flavus* on and off the fields, lead to aflatoxin contamination. This is a very serious food safety concern in food and feed supply chain. Rapid detection of contamination in the maize on-site, preferably with a hand-held instrument, before it comes into the food chain shall help in managing the stored grain.This instrument can be used for rapid detection of Aflatoxin-B1 in maize with an overall accuracy of more than 81% for classifying infected grains into low (<30 ppb), medium (<100 ppb) and high (>100 ppb) aflatoxin content instantaneously.

Jackfruit cutting machine: Jackfruit cutting for bulbs separation is tedious and skilled job. A power operated Jackfruit cutting machine has been developed to ease the operation. The blade assembly is made of four blades of high carbon steel fixed radially on a hollow circular ring. At the centre of the circular ring, a hollow pipe of size 80 mm diameter is fixed for removing the centre core of jackfruit. The unit is driven by 0.75 kW electric motor. The fruit is mounted on the circular ring and the screw rod at the side pushes the movable plate down which in turn presses the fruit against the blades. The cut fruit is collected in a tray at the bottom. The developed machine could cut about 40-60 fruits/h depending on the size of fruits and resulted in saving of about 70% of time as compared to manual method of cutting.

Peeling machine for tender jackfruit: Tender jackfruit is quite popular as vegetable in human diet and now a days tender jackfruit in powder form has been emerged as a novel product and it has many food uses. A peeling machine has been developed for removal of spikey peel of tender jackfruit.The peeling efficiency of the machine has been found to be 90-95% with a peel loss of about 3-4% only at a rotational speed of 80 rpm and linear peeling speed of 0.005 m/s. The machine takes about 40-50 seconds to peel a tender jackfruit weighing about 2.5-3 kg. The machine is operated by an electric motor (1.47 kW) and its output capacity is about 120-130 kg/h.

Power operated baby corn grader: Baby corn occupies an important place in the food processing industry. Tender and fresh baby corns are exported to UK, UAE and Ireland. Proper grading facilities are required for the effective marketing of baby corn. In order to improve the throughput of graded products and to alleviate labour shortage, a power operated baby corn grader has been developed.The machine grades baby corn into five grades, viz. 10-12 mm, 12-14 mm, 14-16 mm, 16-18 mm and >18 mm. Two gear motors of 0.375 kW are used to operate the grader. The performance of the machine was evaluated in terms of grading efficiency and feeding capacity at four roller speeds of 0.7, 1.1, 1.5 and 1.9 m/min. The grading efficiency and feeding capacity of the grader were determined as 94.1%, 94.5%, 90.8 and 85.7% and 258, 307, 437 and 650 kg/h, respectively at the above mentioned roller speeds.



Grain handling, treatment cum bagging system: The mechanized grain handling cum bagging system developed for grain handling during open sun drying. Two counter rotating screw conveyors gather the spread grains. The specially designed inclined bucket elevators pick the grain from flour and convey to overhead hopper. The conveying deck contains about 4.5 kg of grains (wheat) at a time. The conveying deck is also equipped with overhead array of 05 infrared heaters (1,000 W each) to give *in-situ* surface treatment for an early stage disinfestation of grains. The grains are further collected in the attached bag at the discharge outlet of the deck. The machine has a bagging capacity of 0.6 tonne/h free flowing grains.

Solar powered electric *bhatta* for button lac production: Seedlac is refined by means of hot-filtration to produce commercial lac resin, i.e. button lac. *Bhatta* process is the only process used for button lac production. A novel solar powered electric *bhatta* has been developed that completely excludes use of wood/ charcoal and minimizes operator discomfort. Developed *bhatta* resembles the traditional clay *bhatta* in terms of shape and size for easy adoption. It comprises of three units: oven, operator-seat and stone-slab. Infrared heaters are fixed in reflector-heater assembly to act as oven. Single phase (220 V, 50 Hz) electric power supply is provided to the heaters. The developed *bhatta* was operated using PV-based solar power. It filters about 3.0 - 3.5 kg seedlac per hour and consumes about 2.85 kW-h electricity. The developed technology would be very useful in commercial production of button lac as well as hand-stretched shellac.

Development of carboxy methyl guar gum derivative pilot plant: To mechanize the process of carboxymethyl guar gum derivative preparation from guar gum powder with reagents, a pilot plant (capacity: 5 kg/batch) consisting of different units (mixing-cum-

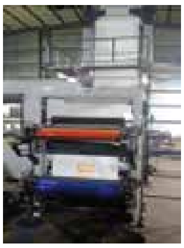
reaction unit, filtration unit, drying-cum-agitator unit, and distillation unit) was developed and installed at ICAR-NISA, Ranchi. Preliminary evaluation of the pilot plant was conducted for carboxymethyl guar gum derivative preparation from guar gum powder. Quality parameters of the carboxy methyl guar gum derivative such as viscosity, pH and degree of substitution were found to be 1230 cP, 8.19 and 0.0183, respectively.

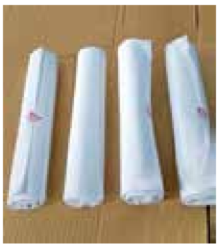
Solar fodder dryer cum winter protection shelter for goats: A polyhouse type solar fodder dryer cum winter protection shelter for goats has been developed. The dryer was used for drying of green biomass (*Cenchrus* spp.), which had initial moisture content of 83.46% (wb). The drying performance of a polyhouse solar dryer (S1) was compared to open sun drying (S2) and shade drying (S3). The polyhouse solar dryer achieved a maximum air temperature increase of 17°C above ambient levels. After 59 h of drying, the moisture content of the biomass was reduced to 9% (wb) in the polyhouse solar dryer (S1), while open sun drying (S2) and shade drying (S3) resulted in moisture contents of 26.5% (wb) and 24% (wb), respectively.

Paddy straw based insulating box: An eco-friendly paddy straw based insulating box has been developed. The size of the insulating box was 300 mm × 300 mm × 300 mm. It is manufactured by using paddy straw blocks made from paddy straw, clay and seed lac. Thermal conductivity of the insulating block is 0.08 W/mK. It is laminated with white emulsion heat reflective coating (solar reflectance - 0.88 and emissivity - 0.91). About 3 kg vegetables can be stored inside the box. The temperature reduction inside the box was 10-12ºC from ambient. The cost of the box is ₹ 600.

Protein-rich jowar muesli: It was developed at ICAR-Indian Institute for Millet Research, Hyderabad and standardized by varying the processing methods of the jowar flakes, including soaking and roasting, combining thick and thin flakes, soaking in protein-enriched liquids, and applying protein coatings. Among these methods, the protein coating process emerged as the most effective, leading to enhanced nutritional content and improved textural and sensory qualities of the muesli. The protein coating method likely facilitated better protein adhesion and uniform distribution on the flakes, resulting in superior taste, crunchiness, and nutritional profile, making it the preferred approach for standardization.

Commercial production of bio-degradable film: The use of plastic-based films has contributed to severe environmental pollution and ecological harm due to their non-biodegradability and persistence in eco-systems. Recognizing the urgent need to address this issue, the Government of India has launched a nationwide campaign to ban single-use plastics, aiming to mitigate environmental pollution and promote the adoption of sustainable alternatives. With this perspective, the institute has developed three types of biodegradable films using the commercial extrusion blown molding method. The technologies developed under the project are Polylactic Acid (PLA) and corn starch based film, PLA and PBAT based film; PLA and Cassava based film. The technology of the developed film was licensed to Natures Bio Plastic Pvt. Ltd., Hyderabad, Telangana. Currently the company is manufacturing 240 tonnes of





Protein rich jowar muesli

Multi-millet mushroom soup mix

Foxtail millet bisi bele bath

bio-degradable film per year and selling at the rate of ` 200 per kg that compares favourably with the market prices of plastic films. The company’s product line includes carry bags, garbage bags, consumer product pouches, vegetable pouches, and head covers, made from the bio-degradable film.

A multi-millet mushroom soup mix: A soup formulation was created using raw materials processed by different methods, such as tray-dried millet powders, slurry-dehydrated millet powders, and fine-milled millet powders. Of these, the slurry-dehydrated millet powders showed the best performance in terms of texture, solubility, and overall sensory characteristics, making them the preferred option for the soup mix. The slurry-dehydration process likely helped retain more nutrients and facilitated better integration of the millet powders into the final product, resulting in improved consistency and higher consumer acceptability.

Ready-to-reconstitute foxtail millet *Bisi bele bath:* It was developed using three different drying techniques: tray drying, freeze drying, and microwave drying. Among these methods, freeze drying yielded the highest quality product, as evidenced by superior rehydration capacity and enhanced sensory attributes, including texture, flavour, and overall acceptability. The freeze-dried *Bisi bele bath* outperformed the other methods, making it the most effective technique for preserving the product’s quality during reconstitution.

Sorghum noodles: These noodles have been standardized through various processing methods, including the use of pre-processed raw materials, incorporation of hydrocolloids, and the addition of stabilizers and other additives. Among these, the incorporation of hydrocolloids has demonstrated superior results, particularly in improving the textural properties and cooking quality of the noodles. Hydrocolloids have been shown to enhance dough elasticity, water retention, and gel formation, resulting in improved firmness and reduced cooking losses, making them the most effective approach in sorghum noodle standardization.

Microbial mediated method of rice straw pulp preparation: Rice straw pulp-plate is an environment friendly alternative of plastic plates which cause environmental menace. We used novel microbial consortium (*Bacillus* sp.: MN784664 + *Penicillium* sp.: MK855473), along with low temperature, 60ºC and low concentration of sodium hydroxide (only 6%) for pulp making. Thereafter physical sieving and hydraulic press is used for plate making. Rice straw pulp-plate is biodegradable and a good alternative of plastic plates.

Rice straw pulp-plate

Curcumin based milk beverage: FSSAI certification was obtained for the Curcumin based milk/beverage mix developed from Turmeric and Ashwagandha at ICAR-CTRI, Rajahmundry.

Rice millet cookies: Cookies, appreciated for convenience and taste, have gained recent popularity as quick snacks. Rice millet cookies, produced at ICAR-NRRI with CR Dhan 310/CR Dhan 315/Black rice flour and ragi flour, utilize modern machinery. Rich in nutrients, they suit diverse group of people. The formulation includes biofortified rice, along with millet and other ingredients such as sugar, milk solids, trans-free fat, salt, and flavouring agents. Blend of rice and millet flour offers unique flavour and diverse nutrient profiles, appealing to various dietary needs.

Ready-to-eat extruded snack products: Extruded snacks, traditionally corn-based, now utilize rice flour as a base, enriched with dal, maize, underutilized leafy greens, and fruit by-products. Developed via twin-screw hot extrusion, these variants boast enhanced protein, anthocyanin, and nutrient profiles. Coated with customizable spices, they offer diverse taste and flavour options in ready-to-eat snacks. These snacks feature a blend of dal, maize, and underutilized greens, providing a broader array of essential nutrients than conventional options.

Flavored rice milk: Ready-to-Serve (RTS) Flavored Rice Milk combines aromatic rice varieties with natural flavoring agents like cardamom, kesar, chocolate, or vanilla. Scientifically formulated and processed, each variant undergoes rigorous techniques to ensure sensory delight and nutritional integrity, representing a fusion of flavor innovation and nutritional excellence.

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11.

Climate Resilient Agriculture

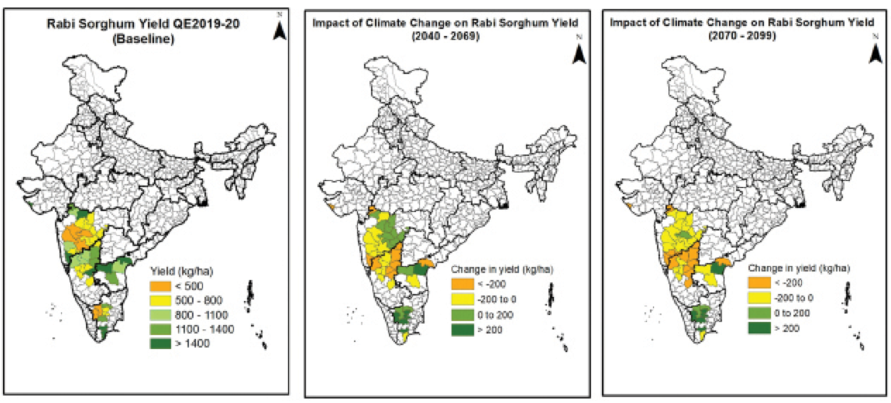
Impact of climate change on productivity was estimated by simulation studies. Studies on greenhouse gas emissions from agricultural practices suggest that residue management and soil type significantly affect emissions of CO_2, N_2O, and CH_4. For example, Vertisol and Inceptisol soils showed varied N_2O flux responses, indicating the need for region-specific approaches in managing agricultural residues to mitigate climate change. Technological advancements, such as the use of digital tools for soil health monitoring and modeling of crop areas under changing climates, provide critical insights for developing adaptive strategies. Innovations like bioethanol production from jute and kenaf also offer sustainable solutions to reduce greenhouse gas emissions, contributing to a low-carbon economy. The development of climate-resilient crop varieties and innovative agricultural practices is crucial for addressing the challenges posed by climate change and improving food security. Several new crop varieties and hybrids have been introduced to enhance yields and resilience. Rice varieties like Swarna Purvi Dhan 1, Swarna Purvi Dhan 2, and Swarna Shusk Dhan were released, all being high-yielding, drought, disease, and pest-resistant, and suitable for water-limited and drought-prone areas. New moth bean varieties, CAZRI Moth 4 and CAZRI Moth 5, outperformed existing varieties, showing significant yield improvements under varied conditions. Mustard strains for organic farming have also been developed, with some varieties like MM16A241 showing higher seed yields than traditional ones. These advancements support sustainable, organic farming practices, which are gaining demand.

Correlation between Climate Change/GHG and Cropping Systems

Impact of residue management and soil type on greenhouse gas emissions in agricultural soils: A study examined the effects of different levels of wheat residue (WR) and nutrient management on greenhouse gas emissions (GHG), specifically CO_2, N_2O, and CH_4, across three soil types: Alfisol, Vertisol, and Inceptisol. Results showed that Inceptisol exhibited negative N_2O flux, attributed to its high legacy phosphorus (19.7 mg/kg), elevated pH (8.49), and lower clay content (13%), which reduced microbial activity as indicated by lower microbial biomass carbon (MBC) and alkaline phosphatase (Alk-P) levels. N_2O emissions were particularly responsive to nutrient inputs in Vertisol with high WR (15 mg/ha), while CH_4 fluxes significantly decreased under high residue inputs, especially in Vertisol and Inceptisol. Alfisol exhibited the highest total carbon mineralization and global warming potential (GWP), with cumulative GWP being 1.2 times greater than Vertisol and 1.4 times greater than Inceptisol across various residue and nutrient inputs. Anthropogenic drivers accounted for 62% of the variance in N_2O responses and 44% in CH_4 responses. These findings highlight the contributions of both anthropogenic and natural factors to agricultural GHG emissions, providing insights for developing process-based models that address climate change mitigation through effective crop residue management.

Impact of climate change on *rabi* sorghum yield in Karnataka and Tamil Nadu: All the *rabi* sorghum districts of Karnataka and most of the districts in Tamil Nadu are expected to witness adverse effects of climate change in 2050s as well as 2080s. In the absence of any technological trend, *rabi* sorghum yield in India is expected to drop to 662 kg/ha in 2050s from current 715 kg/ha. It is further projected to decline to 593 kg/ha in 2080s.

Impact of climate change on wheat productivity: The simulation analysis using the RCM and GCM

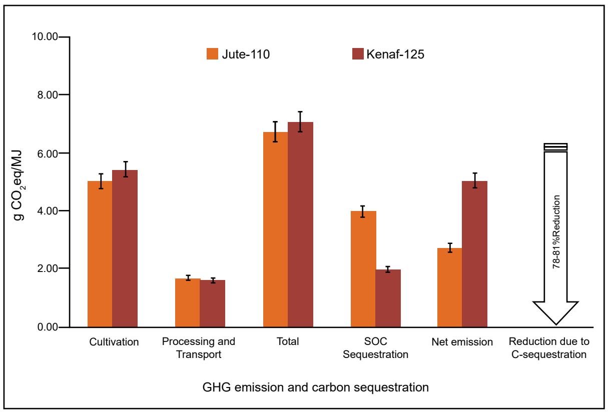


ensemble scenarios indicated that without adaptation, climate change is projected to reduce all-India wheat yield by -9.1% in 2020, -7.7% in 2050, and -6.5% in 2080 under RCP 4.5 emission scenarios. In RCP 8.5 emission scenarios reductions are projected at -21.1% (2020), -17.3% (2050), and -25.9% (2080). State-wise analysis shows that Punjab, Haryana, and Rajasthan may experience yield gains despite climate change under the RCP 4.5 scenario. However, Punjab's wheat productivity is expected to fluctuate between -10% and +15% due to climate change in the near term. In contrast, all other states are projected to see significant yield reductions ranging from 3% to 54% in 2020, with negative impacts expected to increase by 2050 and beyond. Bihar and Madhya Pradesh are anticipated to be the most affected regions for wheat cultivation.

Impact of climate change on irrigated rice productivity: *Kharif* season irrigated rice is projected to experience gains in states like Punjab, Haryana, and Odisha. While the margin of benefit due to climate change varies up to 10% in these states, the assured irrigated rice in Punjab and Haryana is projected to offset climatic risks. Conversely, Odisha is expected to face increased productivity fluctuations year-to-year in future climates, although overall yield improvement is projected to be marginal. Significant negative impacts are projected for all other major rice-producing states, including Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Telangana, Chhattisgarh, and Maharashtra. The analysis indicates substantial inter-annual fluctuations in productivity losses, ranging from 8% to 40% in Telangana and 12% to 30% in Andhra Pradesh and Karnataka. Other states like Chhattisgarh, Maharashtra, and Tamil Nadu are projected to experience productivity losses ranging from -3% to -12% under various climate scenarios. These simulation analyses indicate significant spatial and temporal variations in the magnitude and direction of change in irrigated rice yield if no adaptation is followed.

Climate change impact on alternate cropping system (maize-wheat-mungbean): Climate change impact assessments for maize-wheat and mungbean were being conducted at specific sites, which was extended to set up simulations an all-India level. Additionally, other crops such as pearl millet, soybean, and mustard are being examined as potential alternative crops. Preliminary results indicate a marginal positive effect of climate change on India's overall pearl millet yield, although significant spatial variations exist. States like Punjab, Haryana, Rajasthan, Madhya Pradesh, and Uttar Pradesh are projected to experience significant spatial variability and marginal impacts, with some years potentially facing yield losses due to climatic risks. Further analysis is underway to quantify these impacts more precisely.

GHG emissions for bioethanol production - Potential of jute and kenaf feedstock: Energy security and transitioning to a low-carbon economy are critical for developing nations like India. A study examined the life-cycle GHG emissions and environmental impact of bioethanol production from jute and kenaf feedstock, factoring in soil carbon changes as per the Renewable Energy Directive. The net GHG emissions from crop production and bio-refinery for jute and kenaf ethanol were only 3.45 g/MJ and 5.88 g/MJ, respectively. This was significantly lower than other feedstocks such as sugarcane bagasse, corn stover, rice straw, and wheat straw. Life-cycle assessment (LCA) showed that bioethanol from jute and kenaf can reduce GHG emissions by 78–81% compared to fossil fuels, with minimal environmental impact and resource depletion. This approach could provide 70–75% of India's annual ethanol needs, supporting ethanol-to-petrol blend targets while offering a sustainable, non-polluting fuel source.



GHG emissions for the production of bioethanol (jute and kenaf) and carbon sequestration

GHG emission factors for vegetables, pulses, cereal and other crops: In wheat, N_2O emissions ranged from 0.29 kg N_2O-N/ha in the control to 1.022 kg N_2O-N/ha with 150 kg NCU-N/ha. In sugarcane, emissions ranged from 0.75 kg N_2O-N/ha in the control to 2.58 kg N_2O-N/ha with 200 kg NCU-N/ha. The percentage of applied nitrogen lost as N_2O in sugarcane varied between 0.68% and 0.71% under different NCU treatments. In wheat, the N_2O emission factor (EF) ranged from 0.52% to 0.55%, significantly lower than the IPCC default EF of 1%. For cowpea, the N_2O EF was 0.51%. In potatoes, the N_2O EF was 0.52%, while in onions, it ranged from 0.493% with 120 kg NCU-N/ha to 0.499% with an additional foliar spray of 19-19-19 NPK fertilizer at 60 days after transplanting. For cauliflower, EF of N_2O-N from flatbed

Sampling of GHG emission using close chamber technique in different crops cultivation (0.72%) was higher than that under ridge and furrow cultivation (0.67%). The EF of N_2O-N from ridge (0.56%) was lower than furrow (0.77%). The greenhouse gas intensity (GHGI) was also higher in flatbed system (0.019 kg CO_2 eq/kg curd yield) as compared to ridge and furrow system (0.012 kg CO_2 eq/kg curd yield).

Conservation Agriculture

Evaluation of different cropping systems for crop intensification under conservation agriculture practices: A field experiment under the CRP on Conservation Agriculture (CA) Platform, ongoing since 2015, aims to assess the impacts of location-specific CA practices and crop diversification on crop intensification, soil sustainability, energy budgeting, and the energy-economic relationship in four major cropping systems: rice-wheat, rice-wheat-greengram, maize-mustard-greengram, and sugarcane-ratoon-wheat. The study found that zero-tilled (ZT) wheat produced 17.8% and 17.1% higher yields than conventionally tilled (CT) wheat in the rice-wheat and rice-wheat-greengram systems. Similarly, ZT maize and ZT mustard yielded 14.5% and 19.2% higher than CT maize and CT mustard in the maize-mustard-greengram system. CA-based maize-mustard-greengram and rice-wheat-greengram systems also recorded 17.90% and 16.50% water savings compared to CT-based management practices. Adoption of CA practices led to 31.73% labour savings and 29.71% energy savings. Additionally, soil organic carbon (SOC) improved significantly, with increases of 43.59%, 41.45%, 18.59%, and 17.52% in the CA-based maize-mustard-greengram, rice-wheat-greengram, rice-wheat, and sugarcane-ratoon-wheat systems, respectively, compared to the conventional rice-wheat (CT) system in the 0-60 cm soil profile. Incorporating summer mungbean in the rice-wheat-greengram and maize-mustard-greengram systems (both CA and CT) resulted in 22.58%, 12.84%, and 31.16% higher soil available nitrogen in the respective CA and CT systems compared to the rice-wheat-greengram (CT) system.

Summer greengram in CA based practices

Sugarcane+mungbean intercropping

Paddy Straw Multipurpose Media (PSMM): Each year, millions of tonnes of straw is produced from paddy cultivation especially in areas of Punjab and Haryana, which is invariably burned to quickly prepare the fields for sowing of next crop. This practice of 'stubble burning' becomes a significant contributor to the climate change/global warming. A technique to convert this paddy straw into a low-cost useful multipurpose light weight media having high water retention capacity (CPRI Paddy Straw Multipurpose Media). The same has been commercialized also. It is dispersible, high water retention capacity, light weight, and easy to transport. It could be an alternate cheaper media for healthy nursery raising and protected cultivation of high value vegetables and mushrooms and for hardening of tissue culture produced micro-plants.

Development of climate resilient farming system models in Jharkhand : Agricultural challenges in the Chota Nagpur Plateau, including Jharkhand, involve poor soil fertility, rainfall-dependent farming, and low productivity and income. Integrated Farming Systems (IFS) and Integrated Organic Farming Systems (IOFS) can help address these issues by efficiently recycling available resources. Under the RKVY DPR-based projects of the Directorate of Agriculture, Ranchi, a project titled Development of Climate Resilient Farming System Models in Jharkhand for Food and Nutritional Security and Enhancing Soil Health has been approved for the period 2024-25 to 2027-28. The project aims to develop sustainable farming models that include cereals, pulses, oilseeds, vegetables, fruits, dairy units, and micro-irrigation facilities. Additionally, the models will feature rainwater harvesting units and bunds covered with fodder grasses to reduce soil erosion and provide feed for livestock.

Development of Climate-Resilient Crop Varieties

Release and notification of rice varieties: Three high yielding multiple stress-tolerant rice varieties


Development of water harvesting units in IFS and IOFS model

Swarna Purvi Dhan 1, Swarna Purvi Dhan 2 and Swarna Shusk Dhan were released and notified by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, GoI.

New hybrids in pomegranate: The seedless pomegranate variety Jalore, from Rajasthan, thrives in harsh climates. It boasts high yields, larger fruit sizes, vigorous growth, and increased juice and aril content. To enhance its colour, Jalore was crossed with coloured varieties such as Bhagwa and Mridula. Among 20 F_1 hybrid lines, three hybrids (JSM-2, JSM-10, and JSM-17) showed promise in rind and aril colour, fruit size, and yield. The colour coordinates for rind and aril were highest in CAZRI/JSM-10 (69.5) and CAZRI/JSM-17 (65.7). The fruit yield of these hybrids matched with that of the Bhagwa variety, producing 20-25 kg per plant.

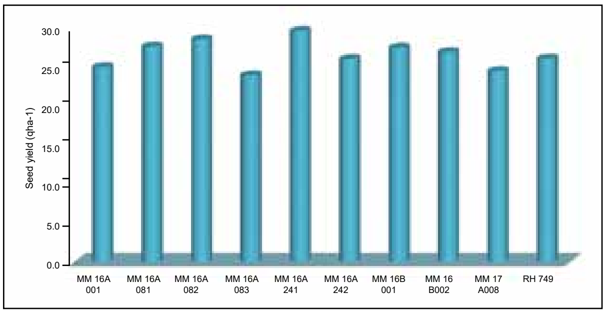
Hybrids of (Bhagwa×Mridula) pomegranate

Moth bean varieties CAZRI Moth 4 and CAZRI Moth 5: The ICAR-CAZRI, Jodhpur has developed two new moth bean varieties: CAZRI Moth 4 (CZMO-18-2) and CAZRI Moth 5 (CZMO-18-5). These varieties exhibit significant yield advantages, with CAZRI Moth 4 yielding 596 kg/ha, representing a 27.4% increase over the best check variety RMO-257 (468 kg/ha), and CAZRI Moth 5 yielding 585 kg/ha, a 25.0% increase. Both varieties also outperformed CZM-2 (436 kg/ha) by 36.7% and RMO-225 (427 kg/ha) by 39.6%, based on three years of data from 15 locations. Both varieties have shown a yield potential over 1,500 kg/ha under optimum management conditions and mature in 70-75 days. Both these varieties retain greenness up to maturity, offering a dual advantage, enabling efficient utilization of extended rainy periods for enhanced yield and providing quality fodder for livestock.

Salient features of released and notified stress-tolerant rice varieties

Variety	Characteristics	
Swarna Purvi Dhan 1 (IET 24660)	An early duration (115-120 days), semi-dwarf, high yielding (4.5-5.0 t/ha), multiple stresses (drought, disease and insect pest) tolerant aerobic rice variety. It is rich in micronutrients, i.e. zinc (20.4 ppm) and iron (13.8 ppm). It is recommended for cultivation under direct-seeded aerobic conditions in water limiting, irrigated as well as drought-prone rainfed area of Jharkhand.	
Swarna Purvi Dhan 2 (IET 26767)	A semi-dwarf, high yielding (5.0-5.5 t/ha), early duration (115-120 days), multi-stress tolerant and fertilizer responsive variety. It is lodging resistant with desirable cooking quality traits and long slender grain type. It is recommended for the cultivation under transplanted conditions in irrigated ecology of Jharkhand.	
Swarna Shusk Dhan (IET 27962)	A semi-dwarf, high yielding (4.0-4.5 t/ha), early duration (110-115 days), multi-stress tolerant and fertilizer responsive variety. It is lodging resistant with desirable cooking quality traits and long slender grain type. It is recommended for cultivation under direct seeded conditions in the drought prone rainfed midland to upland ecosystem of Uttar Pradesh.	

Development of mustard strains for organic production system: The ICAR-IIFSR, Modipuram, has developed high-yielding mustard strains for organic production, responding to the increasing demand for organic products. These strains were derived from F_2 progenies of hybridized indigenous and exotic Indian mustard (*Brassica juncea*) lines. Selected transgressive segregants from the F_2 population underwent continuous selfing and selection up to the F_8 generation to achieve homozygosity. Nine promising homozygous mustard strains were tested against the locally adapted variety RH-749, using 7.5 tonnes/ha of vermicompost and one hand weeding during 2022 and 2023. Among these, MM16A241 (29.7 q/ha) and MM16A082 (28.6 q/ha) significantly outperformed the standard check RH-749 (26.1 q/ha) in seed yield.



Performance of newly derived mustard strains under organic production system

Weed Management

Weed management in finger millet: In transplanted finger millet, weeds reduced grain yield by 48.7%. The best management practice was the pre-emergence application of pretilachlor 30% + pyrazosulfuron ethyl 0.75% WG at 615 g/ha, followed by one hand weeding at 25 days after planting, which resulted in higher weed control efficiency and a grain yield of 2.98 tonnes/ha.

Weed suppressing ability of direct-seeded rice cultivars: Rice variety Purna (98-101 days maturity with an average grain yield of 3.8 t/ha under weedy check) was found to be highly weed suppressive in direct-seeded rice. Other promising weed competitive cultivars identified were Sadabahar (110 days), IR 64 Drt-1 (118 days), Swarna Shreya (120 days), DRR 47 and Swarna Samridhi (130 days).

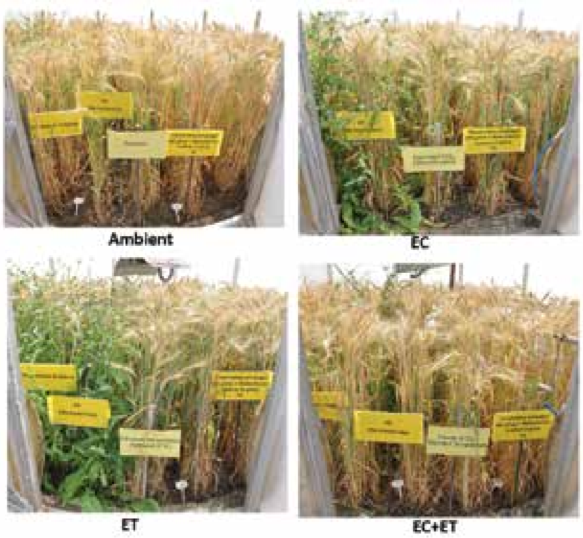
View of control (*left*) and treated (*right*) field of finger millet resulting in 47% higher grain yield

Rice var. Purna

Rice var. Swarna Shreya

Integrated weed management in conservation agriculture systems: In rice-based cropping system, the adoption of integrated weed management [pretilachor + pyrazosulfuron 615 g/ha (PE) *fb* bispyribac sodium 25 g/ha (PoE) *fb* HW in rice; clodinafop+metsulfuron 64 g/ha *fb* HW in wheat; pendimethalin 678 g/ha (PE) *fb* HW in chickpea; and pendimethalin 678 g/ha (PE) *fb* HW in greengram] provided higher system rice equivalent yield (11.3 tonnes/ha), total water productivity (22.0 kg/ha/mm), energy productivity (0.25 kg/MJ) and profitability (2.89).

Impact of elevated CO_2 and temperature on crop-weed interaction and herbicide efficacy in wheat: The efficacy of clodinafop + metsulfuron methyl (64 g ai/ha) against *Cichorium intybus* was delayed by 2-3 days under elevated CO_2 (EC: 550±50 ppm), elevated temperature (ET: Ambient + 2ºC) and under combined effect of EC+ET conditions compared to ambient conditions. This delay in herbicide efficacy had a noticeable negative impact on wheat yield. This yield reduction was further associated with decline in key physiological and biochemical parameters, including reduced photosynthesis rates, relative water content, membrane



Crop-weed interaction and herbicide efficacy under elevated CO_2 and temperature

Biological control of aquatic weed *Salvinia* in Satpura water reservoir

Under a consultancy project, the ICAR-Directorate of Weed Research, Jabalpur successfully cleared approximately 1,100 ha of *Salvinia* infested Satpura Water Reservoir at Satpura Thermal Power Station (STPS) in Sarni, Madhya Pradesh, within 18 months. This was achieved through strategic release and periodic monitoring of insect bio-agent *Cyrtobagus salviniae*. The project not only restored ecological balance but also positively impacted the livelihoods of local fishermen, who had experienced reduced fishing opportunities due to dense weed cover. This success story demonstrates the effectiveness of integrating biological control methods with socio-economic considerations for the sustainable management of aquatic ecosystems.

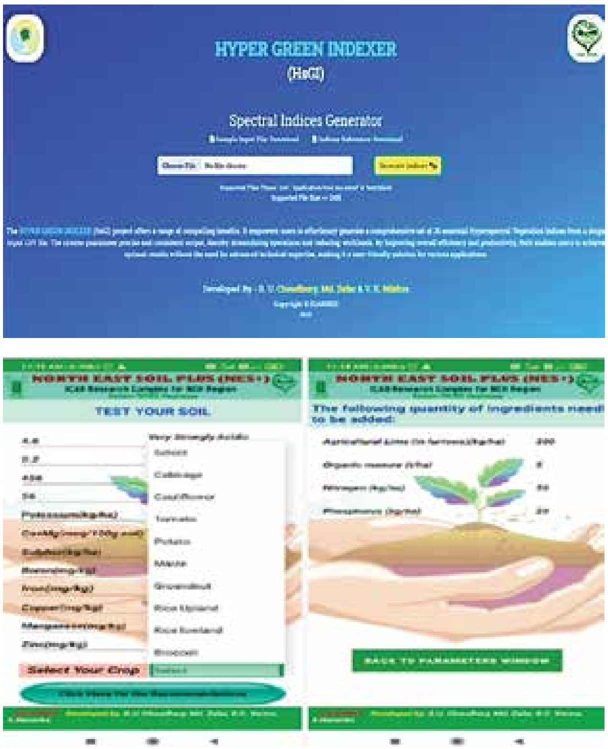
Satpura reservoir before the release of insect bioagents

Satpura reservoir 18 months after the release of insect bioagents

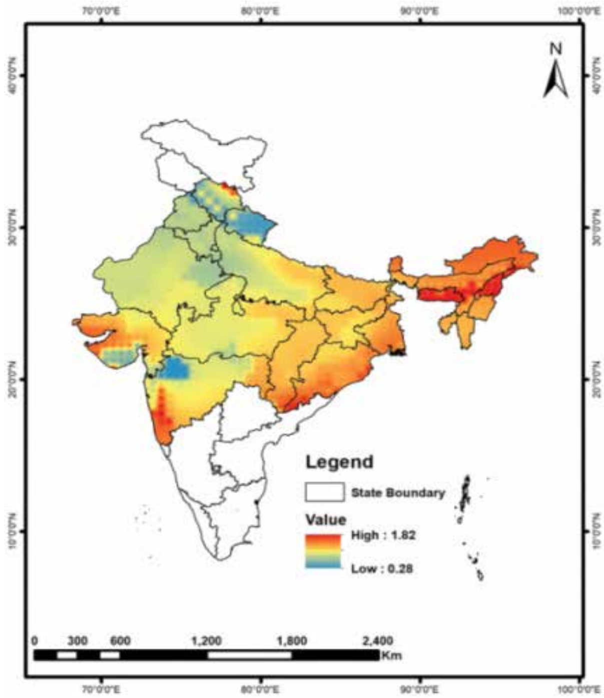
stability index, starch content, and total soluble sugars. Additionally, in unsprayed plots, the growth and biomass of *C. intybus* were found to be higher under EC, ET, and the combined EC+ET conditions compared to ambient conditions, indicating a robust response of the weed to these environmental changes.

Application of Digital Technologies

Advanced digital technologies for soil and crop health monitoring: Under the NICRA project, a non-destructive technology for estimating foliar nitrogen in tomato plants using hyperspectral remote sensing was developed. This technique allows for rapid and accurate nitrogen monitoring, a vital nutrient for plant growth, without the need for conventional destructive sampling. Conducted in Meghalaya, the study also introduced the



Digital tools/technologies developed under NICRA for crop and soil stress monitoring and management



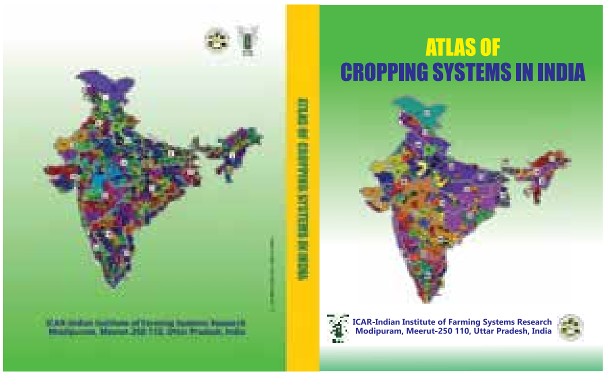
A regional simulation analysis of N_2O emission from major wheat growing areas in India

Hyper Green Indexer (HsGI), a web-based application that generates 26 essential Hyperspectral Vegetation Indices from spectral data. This tool simplifies operations, providing consistent outputs and improving productivity without requiring advanced technical skills. Since its launch, HsGI has been utilized in 236 sessions across seven countries. Additionally, the Northeast Soil Plus (NES+) Android app was developed to assess soil health and offer location-specific nutrient management options for key crops such as rice, maize, pulses, and vegetables.

Simulating N_2O emissions from wheat fields using InfoCrop v2.1 (IPCC Tier III method): The InfoCrop v2.1 model was used to simulate the N_2O emissions from wheat at all-India level. The results indicated that the N_2O emissions are higher in eastern parts and some parts of central India than in NW India. This is largely attributed to higher temperature regimes contributing to higher emissions.

Climate change-based modelling of coconut area: A MaxEnt model-based assessment of habitat suitability for coconut cultivation under future climatic conditions identified key bioclimatic variables, namely, temperature seasonality, annual temperature range and precipitation, as the major factors influencing climate suitability for coconuts in India. Projections indicate that some current coconut-growing regions, such as the plains of South interior Karnataka and Tamil Nadu, may become unsuitable, necessitating a crop change. In contrast, areas like the East coast will require adaptations in genotypic or agronomic management, while climatic suitability for coconut cultivation is expected to increase along the West coast.

Atlas of cropping systems in India: The Cropping System Atlas of India was updated and published. It revealed that the rice-wheat cropping system is the dominant one, covering 15.18 million ha, followed by rice-fallow (10.29 million ha), cotton-fallow (8.81 million ha), soybean-wheat (4.03 million ha), and sugarcane-ratoon-wheat (2.41 million ha). The area under rice-rice and rice-fallow systems has significantly decreased in South India and Gujarat, with these systems being replaced by low-water-requiring crops like cotton, pigeon pea, groundnut, and maize. Further analysis shows that 37.91 million ha are under fallow during either *kharif* or *rabi* seasons. During *kharif*, 5.15 million ha are fallow, mainly due to fallow-gram (1.78 million ha), fallow-wheat (1.15 million ha), fallow-mustard (1.11 million ha), and fallow-sorghum (1.11 million ha). In *rabi*, 32.76 million ha are fallow, primarily from rice-fallow (10.29 million ha), cotton-fallow (8.81 million ha), groundnut-fallow (2.92 million ha), maize-fallow (2.81 million ha), pearl millet-fallow (2.60 million ha), clusterbean-fallow (1.92 million ha), greengram-fallow (1.40 million ha), and pigeon pea-fallow (1.30 million ha) systems.



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12. Agricultural Education

The ICAR continued to play a pivotal role in shaping the future of Agricultural Higher Education (AHE) through its Agricultural Education Division (AED) and associated institutes. This year, a key achievement was the restructuring of the undergraduate curriculum in 13 agricultural and allied disciplines, as recommended by the Sixth Deans' Committee Report, in alignment with the National Education Policy, 2020. The curriculum is designed to be flexible, offering multiple entry and exit points, and integrates the Academic Bank of Credits (ABC) to enhance employability through skill trainings and internships. The ICAR's focus on quality through National Agricultural Educational Accreditation Board facilitated granting accreditation to 37 agricultural universities. A Vice-Chancellors' Conference was held in New Delhi (26-27 February) and Hyderabad (6-8 September) to enhance institutional effectiveness. Virtual meetings with 76 AUs were conducted from February to July, focusing on university achievements, AI in agriculture, and the 'Viksit Bharat' vision. Over 500 participants attended each session. Additionally, a hybrid Editors Workshop in September focused on building research partnerships and enhancing academic publishing. The AED also facilitated student admissions through the Common University Entrance Test, ensuring that only the most qualified candidates are admitted to agricultural universities. The ICAR also provided scholarships, fellowships, and merit-based awards to support students, including national talent scholarships and international fellowships. A notable initiative of Student READY (Rural Entrepreneurship Awareness Development Yojana) programme was enhanced with a new portal and mobile app to foster better connections between students and farmers, allowing students to gain practical experience and contribute to rural development. Three new modules in Experiential Learning Program (ELP) were introduced, including on natural farming, and currently, 496 modules are supported under this programme. Training and capacity building are central to ICAR's mission, and 89 summer/winter schools, short courses, and Centre for Advanced Faculty Training (CAFT) programmes were held at various ICAR institutes and SAUs. The skills, knowledge, and capacity building of 2,047 faculty members were enhanced. The ICAR-National Academy of Agricultural Research Management (NAARM) organized over 80 capacity-building programmes, benefiting thousands of professionals across various agricultural sectors. The National Agricultural Higher Education Project (NAHEP), co-funded by the Indian government and the World Bank and operative since November 2017, came to a conclusion in September 2024. NAHEP's efforts have made a nationwide impact, covering 76 SAUs, DUs, and CAUs, and executed by 62 AUs and 3 ICAR research institutes. By updating curricula, adopting innovative teaching practices, and enhancing faculty expertise, increasing student diversity, and integrating digital tools into the curriculum, NAHEP has transformed agricultural education by enriching the learning experience, inspiring students, and nurturing future agricultural leaders. The project has also seen an increase in the number of applicants for agricultural courses, reflecting the growing interest in the sector.

The ICAR continues to play a central role in shaping the future of agricultural higher education (AHE) in India, through its Agricultural Education Division (AED), navigating the evolving agricultural landscape, addressing emerging challenges, and seizing new opportunities. Supported by public funding, India is home to a network of 66 State Agricultural Universities (SAUs), 4 Deemed Universities (DUs), 3 Central Agricultural Universities (CAUs), and 4 Central Universities (CUs) with Agricultural Faculties and approximately 364 affiliated agricultural colleges. All of these institutions operate under the National Agricultural Research, Education and Extension System (NAREES),

Overview of publicly-funded AUs in India and the number of courses offered in agricultural higher education which is overseen by the ICAR. This network fosters innovation, ensuring the delivery of high-quality education in the field. The AED runs the scheme on 'Strengthening and Development of Higher Agricultural Education in India', under which financial support is provided to ICAR-accredited Agricultural Universities (AUs). The Agriculture Education Portal (https://education.icar.gov.in/) serves as the comprehensive gateway encapsulating all initiatives of AED. Major achievements are given below.

Quality Assurance and Reforms in AHE

Sixth Deans' Committee Report: A major achievement during this period was the approval of the Sixth Deans' Committee Report, which led to the restructuring of the course curricula for 13 Undergraduate (UG) disciplines in agriculture and allied sciences, aligning with the National Education Policy (NEP-2020). The report was shared with Vice-Chancellors of SAUs and other universities for implementation starting in the 2024–25 session. The revised curriculum introduces new courses of national and global importance, including artificial intelligence, machine learning, robotics, precision farming, natural farming practices, carbon reduction, nutrient efficiency, and agricultural export practices. It offers a student-centric approach with flexible course selection, multiple entry and exit options, and various qualifications. Additionally, the curriculum integrates the Academic Bank of Credits (ABC), emphasizes employability through skill development in specialized areas, and offers opportunities for entrepreneurship and internships. Another change from the Fifth Dean's Committee Report (2015) is the increase in curricula flexibility by each AU from 10–30%, to cater to local agro-ecosystem.

Course	Duration
UG Certificate	Exit after 1 year
UG Diploma	Exit after 2 years
UG Degree with Honors	Completion of 4 years

Accreditation of Agricultural Universities (AUs): Accreditation is a continuous process conducted by the National Agricultural Educational Accreditation Board (NAEAB) of ICAR, based on requests received from eligible universities offering agricultural degree programmes in the country, by assessing them in accordance with Deans' Committee reports, BSMA recommendations, ICAR Model Act, and guidelines developed by the Board over the past 25 years. During 2024, a total of 60 Peer Reviews were conducted and final Peer Review Team (PRT) reports were submitted to the NAEAB for consideration. Of these, 37 AUs were approved for accreditation. Out of the 12 appeals received and examined by the Board's Appeal Committee, four PRT reports were recommended for accreditation. Among six sub-committees constituted by the Board to cross-examine PRT reports, three were recommended for accreditation. From January 2024, a total of 50 applications have been received through the accreditation portal. Currently, 21 PRTs have been constituted, and SSR verification is underway. Other reports have been returned to universities for resubmission after necessary modifications.

Coordination with AUs: This initiative aimed to provide VCs of AUs with opportunities to interact, exchange ideas, and develop strategies for enhancing institutional effectiveness. This included ensuring quality standards in AHE nationwide and facilitating the successful implementation of new initiatives. To this end, a 'Conference of Vice-Chancellors, Directors, and Industry' was held in New Delhi from 26-27 February, 2024, and an 'Interaction Meeting cum Vice-Chancellors' Conference' was organized in Hyderabad from 6-8 September, 2024.

In 2024, ICAR launched a new initiative to organize virtual meetings with all 76 AUs across India. The aim was to promote knowledge-sharing, showcase university programmes, and encourage collaboration between AUs and ICAR institutions. These meetings were held every Saturday from 10 February to 27 July, featuring VCs from three or four universities in each session. The VCs presented their universities' achievements and future goals in education, research, and extension. The sessions also addressed emerging topics such as the application of Artificial Intelligence in agriculture, technology transfer partnerships, and the vision of "Viksit Bharat." Each meeting attracted over 500 participants, including VCs, faculty, students from AUs, ICAR and KVK officials, scientists, and NAAS fellows. This initiative fostered enhanced collaboration, facilitated knowledge exchange, and strengthened partnerships within India's agricultural education and research ecosystem.

Additionally, an Editors Workshop on 'Enabling a Research Ecosystem' was organized by AED in hybrid mode on 24 September, 2024 in New Delhi. The workshop aimed to build partnerships among researchers, editors, and publishers, equip researchers with publication skills, and discuss the future of academic publishing with a focus on innovation, ethics, and accessibility. Key speakers provided valuable insights on editorial standards, publication impact, and enhancing research performance using tools like CERA and the Scopus database. Over 1,000 participants, including VCs, ICAR Directors, ADGs, deans, faculty, scientists, librarians, and students from ICAR and AUs, attended the event, contributing to its success and impact.

Strengthening and modernizing teaching and learning facilities in AUs: A financial assistance of ₹ 3,288 lakhs was provided during the year by AED to AUs, under the component 'Development and Strengthening of AUs'. This support covered ongoing projects, including the construction of one auditorium and new civil works for two boys' hostels and eight girls' hostels. Additionally, funds were allocated for the modernization and upgrading of infrastructure related to teaching and learning. Teaching facilities were

Modernization of laboratories

further enhanced with additional support for 38 smart classrooms. Undergraduate (UG) and postgraduate (PG) laboratories were strengthened with major/minor equipment, aimed at improving students' practical experience and supporting research activities.

Admission to Agri-Courses Facilitated by ICAR

Common University Entrance Test (CUET) for admission to UG programmes: The CUET for admission to UG programmes for 5,221 All India Quota (AIQ) seats and the National Talent Scholarship (NTS) was conducted online in Computer-Based Test (CBT) mode by the National Testing Agency (NTA) from 21 June to 5 July, 2023. This marked the first instance of the examination being held in this format. Among the AIQ seats, 20% (including 100% of seats at ICAR-IARI, New Delhi; ICAR-NDRI, Karnal; RLBCAU, Jhansi; and Dr RPCAU, Pusa) were allocated to degree programmes in Agriculture and allied disciplines (12 fields), excluding Veterinary Sciences, offered by AUs under the ICAR-AU system. A total of 1,57,041 applications were received, and 1,22,621 candidates (78.08%) appeared for the exam. Of these, 82,425 were female, 74,613 were male, and 3 were transgender candidates. Among the categories, the highest participation was from OBC (NCL) candidates (69,893), followed by General (49,359), SC (16,474), General-EWS (11,628), and ST (9,687) candidates.

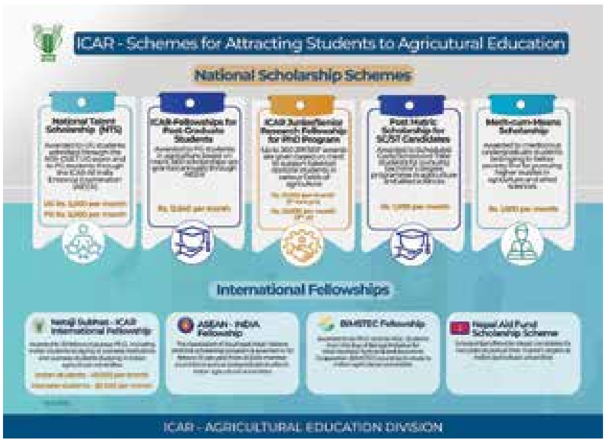
All-India Entrance Examination for Admission (AIEEA) to PG: The 28 AIEEA-2023 (PG) online examination was conducted on 9 July, 2023, for admission to 30% of seats (including 100% of seats at ICAR-DUs, RLBCAU, Jhansi, and Dr RPCAU, Pusa) in PG programmes, along with the ICAR-PG Scholarship and NTS. Of the 27,358 applicants, 24,948 (91.19%) appeared for the examination, with a nearly equal gender distribution: 12,080 female and 12,868 male candidates. Among the categories, OBC (NCL) candidates constituted the largest group (9,789), followed by General (7,348), SC (3,686), ST (2,217), and General-EWS (1,908).

All-India Competitive Examination (AICE) for PhD Admission and Award of Junior/Senior Research Fellowship: The online examination [28th AICE-JRF/SRF (Ph D) 2023] was conducted on 9 July 2023, for admission to 30% seats (100% seats of Dr RPCAU, Pusa; RLBCAU, Jhansi; and ICAR-DUs-4No.) in PhD programmes, including the award of Fellowships. A total of 8,880 candidates (90.97%) appeared in the examination out of 9,761 applicants. Of these, the number of female candidates (4,834) was higher than that of male candidates (4,046). Among the categories, OBC (NCL) candidates were the highest (3,180), followed by General (2,892), SC (1,420), ST (645), and General-EWS (743).

Scholarships/Fellowships in AHE

Student-centric schemes: The AED facilitates in awarding national scholarships and international fellowships to recognize talent and promote merit, particularly for encouraging talented students to pursue AHE.

Scientist-centric schemes: ICAR fosters excellence by recognizing exceptional scientists through its National Professor, National Fellow, Emeritus Professor, and Emeritus Scientist programmes. These initiatives promote basic research, cultivate new ideas, and utilize senior scientists' expertise in teaching, research, and



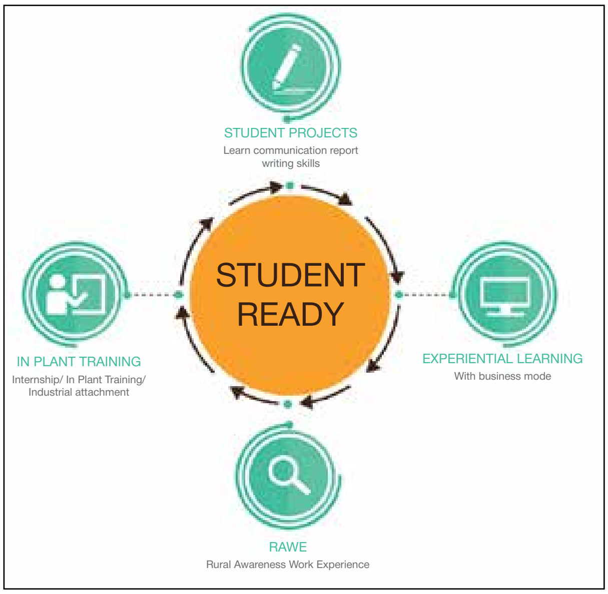
Scholarships and Fellowships awarded

Award of Scholarships/Fellowships (2024-25)

Scholarship/Fellowship		No. of recipients/awardees
National Talent Scholarship (NTS)	UG students admitted through the ICAR All India Entrance Examination (AIEE)	9,943
	PG students admitted through ICAR-AIEE	5,207
ICAR Fellowship for Post-Graduate Students	PG Scholarships for Master's studies	1,605
	JRF/SRF Fellowships for doctoral studies	1,037
Merit-Cum-Means Scholarships		446
Internship Allowance	For veterinary graduates	3,929
Netaji Subhas-ICAR International Fellowship	30 fellowships are available annually	4 Indians and 1 from Nepal

ASEAN-India Fellowship for Higher Education in Agriculture and Allied Sciences

The ASEAN-India Fellowship for Higher Education was launched by Union Minister of Agriculture and Farmers' Welfare and Rural Development Shri Shivraj Singh Chouhan in the presence of Union Ministers of State for Agriculture and Farmers' Welfare, Shri Bhagirath Choudhary and Shri Ram Nath Thakur on August 14, 2024. Starting from the academic year 2024-25, a total of 50 fellowships (10 per year) will be awarded to students from ASEAN member countries for a master's degree in emerging fields of agriculture and allied sciences. Participating Indian faculty members will be facilitated with introductory visits to ASEAN member countries to aid ASEAN capacity-building which will promote the development of a pool of expert human resources in ASEAN for the growth of agriculture. The long-term degree courses in India would help researchers from both regions stay connected for a long time and better understand agriculture-related issues in ASEAN countries and India.



resource development. During the reporting period, four National Professors and seven National Fellows were in position. Additionally, 21 Emeritus Scientists and 37 Emeritus Professors advanced research, guided PG students, and developed e-learning resources. Many also mentored students and published advanced teaching materials and books. Salient research achievements from these schemes are provided in Chapter 15.

Student READY Programme

App Launched: The Student READY (Rural Entrepreneurship Awareness Development Yojana) programme, initiated in 2015, aimed to provide rural entrepreneurship awareness, practical experience in real-life situation in rural agriculture and creating awareness to UG students about practical agriculture and allied sciences is being typically conducted during the 7th semester. In September 2024, a workshop on Student READY portal and Rural Agricultural Work Experience (RAWE) App (VIKAS) was organized for UG students in AUs and demonstrated by the AED to >800 senior officers of all the AUs. The App is a collaborative interdepartmental effort of DA&FW and ICAR, developed by ICAR-IASRI and Digital Green. This new app shall collect feedback on DA&FW schemes by students of agriculture colleges during RAWE programme and help for better connect between students and farmers. Students contribute by sharing knowledge on the latest advancements in agriculture and allied areas with farmers. This includes providing information on new technologies, crop protection methods, and more. Additionally, students gain practical experience by managing commercial farms and visiting progressive farmers. They also visit agri-industries, gaining insights into various agri-business operations. This hands-on training bridges the gap between theoretical knowledge and practical application, tailored to the specific needs of each discipline. During the reporting period, 24,352 students completed training under the RAWE programme.

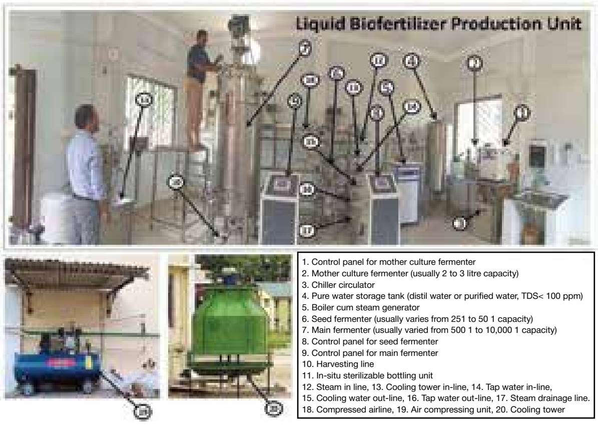
Three new modules in Experiential Learning Program (ELP) were introduced last year, including natural farming, and currently, 496 modules are supported under this programme.

Training and Capacity Building

Summer/Winter schools and short courses: All training programmes sponsored by the AED were monitored through a workflow-based online management system. During the reporting period, 89 summer/winter schools and short courses were organized, comprising 37

ELP on model natural farm
Preparation of bio-cultures
Industry-scale production of liquid biofertilizers using native, efficient biofertilizer agents
Production of bioagents using native, effective antagonists
Beekeeping to promote the natural population of pollinators
Conversion of organic farm waste into organic manures
Production of quality seeds of field crops under natural farming practices
Production of quality planting materials for horticultural crops by adopting natural farming practices
Livestock and poultry production under natural farming systems
Desi cow-based natural farming activities
Silvi-horti-apiculture-based activities
Production of spawn and mass cultivation of edible and medicinal mushrooms as part of natural farming activities
Value-addition to natural farm products

Beekeeping in Silvi-Horticulture system as component of natural farming practiced by students under ELP on natural farming activities at CoA, Kyrdemkulai (under CAU, Imphal)



Liquid Biofertilizer Production Units developed at six constituent colleges of CAU, Imphal

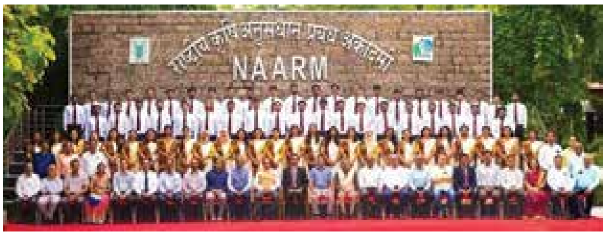
Conversion of agriculture wastes to organic manures under ELP activities

summer/winter schools of 21 days, 25 short courses of 10 days, and 27 Centre for Advanced Faculty Training (CAFT) programmes at various ICAR institutes and SAUs. The skills, knowledge, and capacity building of

An ELU for oyster mushroom production

2,047 (1,368 male/679 female) faculty members were enhanced.

Capacity building at NAARM, Hyderabad: The ICAR-National Academy of Agricultural Research Management (NAARM) organized 80 capacity-building programmes benefiting approximately 16,065 participants to address the diverse capacity needs of professionals. These programmes catered to Research Management, Scientific, Technical, and Administrative Cadres of ICAR, Faculty from AUs, young agribusiness professionals, and marketing officers from the industry, as well as skill development programmes for farmers and sensitization programs for students. The Academy also offered Foundation Courses for newly recruited Agriculture Research Services (ARS) scientists and faculty of SAUs to improve teaching, research, and extension competencies.



Batch of 113th Foundation Course for Agricultural Research Services held during 18 July-17 October 2023

ICAR-NAARM's two-year Post Graduate Diploma in Management (PGDM) in Agribusiness Management (ABM) is AICTE and NBA accredited, with MBA equivalence from the Association of Indian Universities (AIU). The 15th and 16th batches have 61 and 57 students, respectively. All 57 students of the 2022-24 batch secured placements across 30 reputed agribusiness firms, with packages ranging from ₹7.5 to 12.5 lakh per annum (lpa) and an average CTC of ₹9.5 lpa.

Additionally, ICAR-NAARM offers one-year online diplomas in Technology Management in Agriculture (DTMA) and Education Technology Management (DETM) in collaboration with the University of Hyderabad. Final exams for DETM and DTMA backlog students were completed in December 2023 and July 2024, respectively, with certificates uploaded to DigiLocker.

Digital initiatives: The Centre of Lifelong Learning in Agricultural Education (COLLAGE) at ICAR-

NAARM supports digital content development for education, creating 75 interactive video modules for various Massive Open Online Courses (MOOCs). These include ICAR-NAARM courses on AI in Agriculture and Digital Assessment, along with ICAR-NDRI courses on Dairy Technology, Cheese Science, Food Packaging, and Fat-Rich Dairy Products. Since October 2023, ICAR-NAARM has also launched two MOOCs, reaching 5,924 learners nationwide. To enhance digital education, the lab now features a state-of-the-art Multi-input Digital Content Production Unit for high-quality, and rapid content production.

Start-ups and agripreneurship: Since 2014, the Association for Innovation Development of Entrepreneurship in Agriculture (a-IDEA), the Technology Business Incubator of ICAR-NAARM, has promoted agribusiness startups. Between October 2023 and September 2024, it organized two programmes for ICAR-ABI Centers and startups, with NABARD supporting 9 startups through *KRISHIBOOT* and 12 through Agri*Udaan*. Funding of ₹ 50 lakh each was provided to seven startups under BIRAC BIG, and ₹ 10 lakh each to 10 startups under *Nidhi Prayas*, with additional funding through NABARD CCF and SISF. Notable events included *Aggnite* 4.0, which awarded three students, and Agri*Udaan* 6.0, which concluded with a demo day attended by 30 investors. Recognized as a Resource Support Agency for 104 FPOs in Andhra Pradesh by NABARD APRO, a-IDEA also launched an Agribusiness Management Development Programme for prospective CEOs, aiming to place 85 in FPOs across Telangana, Andhra Pradesh, and Maharashtra. Three immersion programmes involving over 300 farmers, 120 FPOs, and 22 startups fostered collaboration and networking, earning recognition from ICAR on its 96th Foundation Day. The Second Graduation Ceremony of Agri-Startups celebrated 43 startups from 13 states and 12 sectors and was held at ICAR-NAARM on 23 January 2024. Further, a-IDEA, signed MoA with 16 ICAR institutions for providing support like co-incubation, co-events, technical mentoring and monitoring, etc.

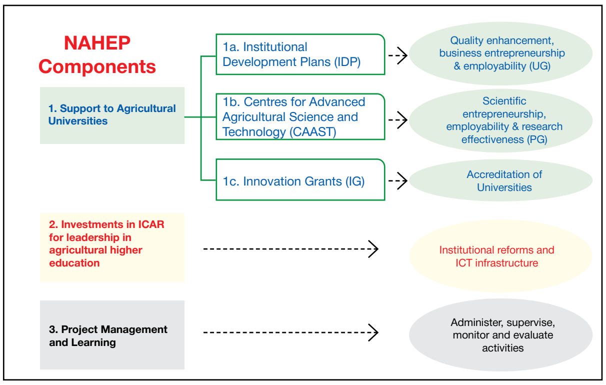
MoUs: ICAR-NAARM, Hyderabad signed Memorandum of Understanding (MoU) with two universities, namely, Kamdhenu University, Gujarat on 18 October 2023, and SR University, Warangal on 12 February 2024, to facilitate staff and student trainings and guiding in their research work. These MoUs have been very important in the process of implementation of NEP

MoU Signing Ceremony between ICAR-NAARM and SR University, Warangal, on 12 February 2024

2020. The Academy also signed Tripartite Memorandum of Understanding with Dr YSR Horticultural University, Venkataramannagudem, Andhra Pradesh, Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka and Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu with ICAR-National Academy of Agricultural Research Management and National Agricultural Higher Education Project, New Delhi, to pursue collaborative academic activities that enhance excellence in Agricultural Education through establishment of Career Development Centre (CDC).

National Agricultural Higher Education Project (NAHEP)

The NAHEP, a mega network project of the ICAR co-funded equally by the Central Government and World Bank, operative since November 2017 concluded on 30 September 2024 (https://nahep.icar.gov.in/). It was implemented by 62 AUs (SAUs, DUs, and CAUs) and 3 ICAR research institutes but impacted many National Agricultural Research and Education System. (NARES) institutes across the nation. The NAHEP aimed to improve the quality of agricultural education by helping AUs implement projects that enhance faculty performance, attract top students, improve learning outcomes, and boost employability.



During the reporting period, focus was given on organizing agri-fairs, training and skill entrepreneurship programmes to enhance attractiveness of agri higher education. In terms of monitoring and evaluation of the project, data was collated on Agricultural Resilient Education Systems (RAES) effectiveness index (contributing 10% of project outlay) and graduate income increase (GII) index. Further, a pilot for implementation of action plan of mainstreaming agriculture curriculum in school education (MACE) was rolled out. All NAHEP partners also developed sustainability plan.

The number of applicants for entry-level exams in AHE has risen from 1.5 lakh in 2017-18 to 5.1 lakh in 2022-23, reflecting a compound annual growth rate (CAGR) of 22.6%. The number of applications per seat for the entry-level agricultural exam has risen from 75 to 119, indicating a clear increase in competitiveness and demand. In contrast, when comparing the total number of applications per seat for all UG programmes

Evidence of attribution of NAHEP grants leading to project outcomes

Indicator	Unit of measurement	Baseline (2016-17)	Achievement till September 2024
Increase in on-time graduation rate of AUs	%	77	96.1
Increase in student placement rates	%	41	67.0
Increase in student diversity	%	19.2	25.8
Increase in faculty diversity	%	45	54.1
Increase in faculty research effectiveness	H-index	21	31.2
Improved AU revenue generation	%	8.5	16.1
Number of industry-sponsored projects and positions in cutting edge areas	Number	187	444
Direct project beneficiaries	Number		8,26,761
Female beneficiaries	%		51

(both agricultural and non-agricultural) nationwide, it was found to be just 24, roughly one-fourth of the applications per seat for AHE exams. This growth highlights NAHEP's contribution to making AHE more appealing.

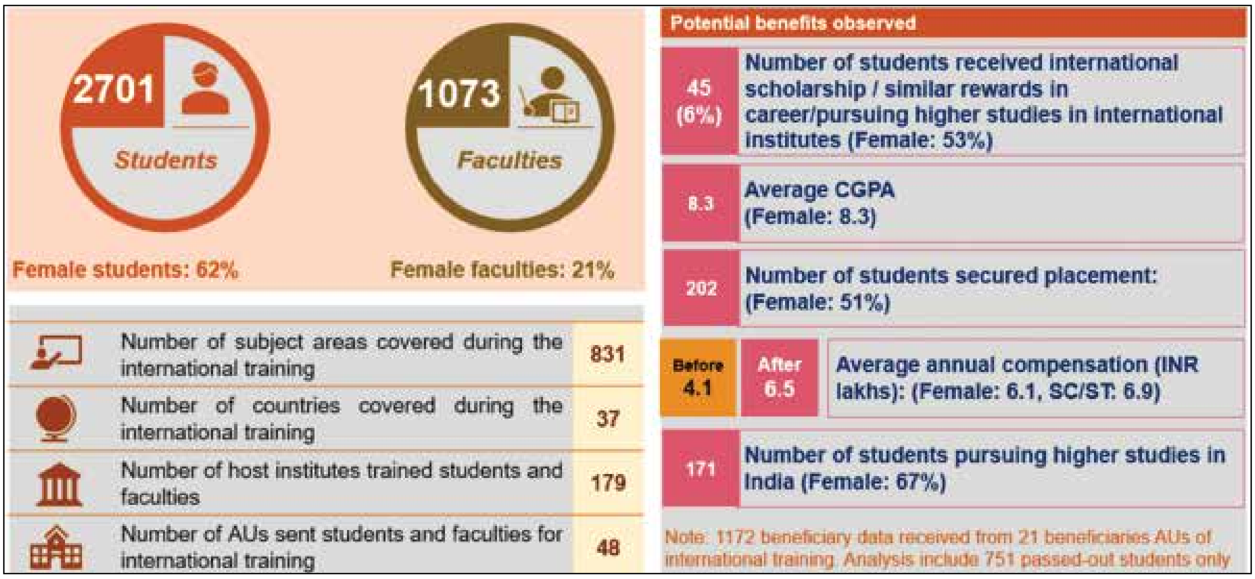
The overall internal revenue generation of partner AUs has increased from 8.5% of total revenue in 2017-18 to 16.1% in 2023-24. Similarly, the budget of the overall ICAR-AU ecosystem has increased from ₹ 9,000 crore in 2017-18 to ₹ 14,500 crore in 2023-24, registering an 8.2% CAGR growth.

To prepare students for the job market, partner AUs implemented skill-building programmes, market-focused pilot courses, and industry collaborations. Over 600 courses were developed with national and international higher education institutes and industry partners, many now integrated into the regular curriculum. Key activities included vocational training, industry exposure visits, and communication skills development. Students and faculty from partner AUs visited more than 200 higher education institutions (HEIs) across 45 countries globally under NAHEP. These AUs saw an improved placement rate, rising from 36% in 2017-18 to 67% in 2023-24. Notably, 45 students from these programmes earned international scholarships or pursued higher studies abroad, with more than half being women.

NAHEP's efforts have shown a clear link between higher income levels for agricultural graduates compared to non-agricultural graduates. According to the Graduate Income Index (GII) survey, about 27% of beneficiary agricultural graduates earned at least 20% more than the national average for graduates. Additionally, female agricultural graduates earn incomes nearly equal to their male counterparts.

Impact of Facilitative Units: NAHEP-funded sub-projects focused on establishing 749 facilitative units across campuses, including advanced labs, modernized classrooms with AR/VR, e-learning studios, and language labs. These facilities enhanced research, learning outcomes, and provided world-class experiences for students and faculty. They also enabled hands-on training in emerging technologies and generated revenue for some AUs. These units significantly boosted faculty research capabilities, leading to an increase in externally funded projects from 28 in 2017-18 to 444 in 2023-24. Average revenue per faculty member rose from ₹0.4 lakh to ₹1.9 lakh during this period, with over 20% of beneficiaries earning promotions or better positions.

Impact of investments in ICAR for leadership in AHE, including Resilient Agricultural Education System (RAES): Component 2 of NAHEP made notable progress in modernizing agricultural education in India by utilizing digital technologies and enhancing



Overview of impact of International Trainings conducted under NAHEP

Out of total 749 facilitative units established under NAHEP. (N=445 units)

Number of facilitative units established	
Without NAHEP	With NAHEP
51	445

Type of establishments		
Type of units	Number of units	Avg. Cost incurred (INR Lakhs)
Research Lab upgradation	258	32.9
Digital Lab/Virtual/Smart Classrooms	93	63.6
Out of box initiative	43	137.2
Upgradation of existing academic facilities	23	14.2
E-Content repository	12	23.5
Incubation centre	8	10.3
Placement/Alumni/IIIC Cell	6	23.4

Potential benefits observed (intermediate)

Stakeholder	Category	Benefits observed
Student	Enhanced CGPA	• 1-2% per year
	Increased attendance rate	• 10-15%
Faculty	Increased number of external funded projects	• From 1 project/faculty to 3/faculty
	Enhanced research efficiency	• Avg. Reduced Cost: 10-20% • Avg. lead time reduction: 20-30%
	Increased revenue/faculty	• 0.4 to 1.9 Lakhs/faculty

Source: Data from 21 AUs and 445 facilitative units, in-person interaction with ~10AUs, sub-project closure reports, case studies etc. September 2024

Assessment of Facilitative Units established under NAHEP

capacities across ICAR-AUs. It sed focus on four key areas: strengthening IT infrastructure, building new capacities, developing a digital content repository, and boosting overall digital capacity. A major outcome is the development of an 'E-learning Portal' (https://elearning.icar.gov.in/) offering a cohesive agricultural education experience, in alignment with BSMA and the Fifth Dean's Committee. The portal caters to diverse learning needs, providing resources like e-course content, online exam platforms, virtual learning spaces, PPTs, glossaries, MCQs, and assessments. Contributions from faculty at 74 AUs foster an inclusive environment, offering varied content to enhance understanding and enable self-assessment for students from different backgrounds. This collaborative effort has resulted in the creation of 145 UG courses and 71 PG courses. The portal has a monthly average of 18,000 views with 9,000+ downloads per month.

Key features of NARES-BLP

A major output of the RAES subproject under NAHEP was the development of the Indian National Agricultural Research and Education System (NARES) - Blended Learning Platform (BLP), for all 76 AUs. The BLP is Learning Management System that seamlessly combines traditional classroom teaching with the power of online learning, ensuring that education continues uninterrupted, regardless of external circumstances, where learners can access knowledge anytime, anywhere, and at their own pace. The platform aims at inculcating

AR/VR lab established at TANUVAS for enhanced learning experience of students

a digital first mind amongst learners and faculty and act as a catalyst for introducing more engaging forms of classroom instruction while also providing flexible learning mechanisms to learners. More than 93,000 users have already been on boarded on to this platform and a total of 59 2D/3D (PG courses: 12, UG courses: 47) digital contents have been developed. Since its launch, the BLP has on-boarded over > 1 lakh users, including faculty and students.

Further, significant efforts have been made to harness the potential of artificial intelligence (AI) such as optimizing crop disease identification, teaching courses in classrooms, and simplifying complex concepts for students. Through data-driven insights, farmers are empowered to make informed decisions about their crops (e.g. AI-DISC) and students are able to equip themselves with the changing world of technology. Virtual reality (VR) and Augmented Reality (AR) technologies can simulate both natural environments and controlled scenarios, offering students a dynamic learning experience within the classroom. They can virtually explore farms, dissect complex biological processes, and experiment with agricultural practices. All collaborating AUs have been well-equipped with AR/VR facilities, and faculty members trained to develop learning modules suitable for AR/VR applications.

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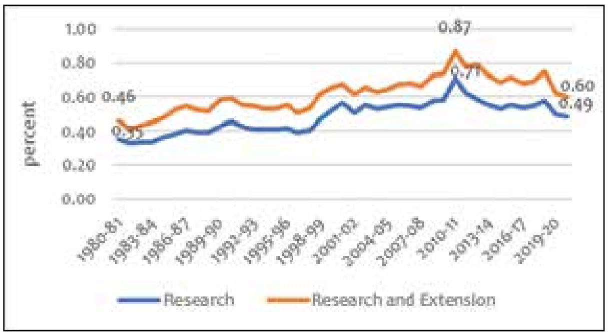
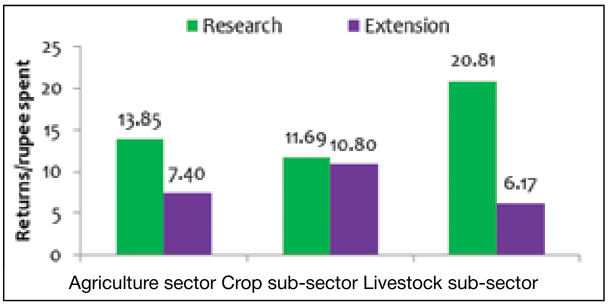
13. Social Science

The potential for strategic policy interventions, innovative research, and technology integration are fully realized and integrated into the ICAR's programmes and schemes to address India's agricultural challenges and ensure sustainable development. India's agricultural R&D expenditure has declined significantly, dropping from 0.87% of agricultural GDP in 2010–11 to 0.60% by 2020–21. Despite its high productivity, with research yielding ₹13.85 and extension services ₹7.40 per rupee invested, the allocation remains skewed. Crops dominate the funding, receiving 83% for research and 92% for extension, whereas the cattle sector, contributing nearly one-third of agricultural GDP, gets only 10.2% and 6.2%, respectively. Animal science research, being almost twice as productive as crop research, underscores the need for balanced funding. To address this, increased investment in underfunded areas like livestock, fisheries, and natural resources is essential for equitable and sustainable development. The Government of India has initiated schemes like PM-KUSUM for solar pumps and PDMC under PMKSY for micro-irrigation to address groundwater and energy issues. However, these technologies are adopted disparately, with states like Karnataka excelling in micro-irrigation but lagging in solar pump adoption, and vice versa for Chhattisgarh. Integrating these technologies could enhance water and energy efficiency, boost crop yields, and reduce CO_2 emissions by 45 million tonnes annually. Achieving this requires institutional restructuring, innovative financing, and tailored system designs to unlock their combined potential. In Punjab and Haryana, groundwater regulations aligning paddy sowing with monsoon onset have failed to halt depletion due to subsidized electricity, farmers' preference for high-yield paddy, and assured procurement. Paddy cultivation now covers 88% of Punjab's and 52% of Haryana's kharif-cropped areas. Solutions include rationalizing electricity subsidies, promoting water-saving technologies like tensiometers and direct seeding, revitalizing canal irrigation, and incentivizing crop diversification through compensation for revenue losses. Vegetable price volatility arises from seasonality, climatic variations, and inefficient supply chains. Addressing this requires developing climate-resilient varieties, investing in cold storage, and improving transportation to reduce post-harvest losses. These measures can stabilize prices, ensure fair returns for farmers, and reduce consumer impact. Agriculture's vulnerability to climate risks is significant, particularly at localized scales. A vulnerability index developed for Uttar Pradesh highlights areas at risk, especially in the eastern regions. This granular mapping enables targeted adaptation strategies to mitigate climate impacts on agriculture and livelihoods. ICAR's policy advocacy focuses on strengthening extension systems, developing agri-infrastructure, and mainstreaming farmer innovations. Advancements in statistical methods support efficient agricultural research. The Post-stratified Rescaling Bootstrap (PstRUBD) provides unbiased variance estimates for dual-frame surveys. The Geographically Weighted Spatially Integrated (GWSI) estimator integrates survey data for accurate population totals. Experimental designs like Dichotomized Split-Set Schemes and Semi-Latin Rectangles improve efficiency and resource use in trials. A web application for Semi-Latin Rectangles is now accessible for quick design generation, enhancing experimental flexibility. Thus, addressing India's agricultural challenges requires a balanced approach to R&D investments, integration of advanced technologies, and sustainable resource management.

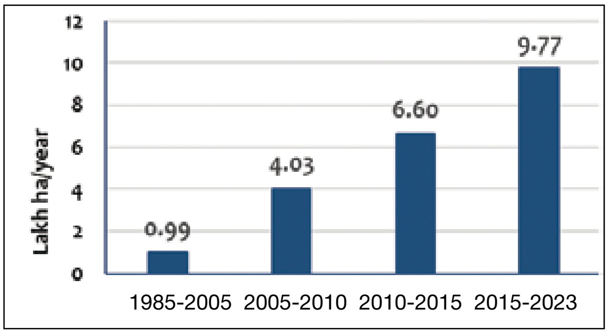
Refining Agricultural Economic Policies for Better Outcomes (ICAR-NAIP, New Delhi)

Evaluating the impact of public spending on agricultural R&D: Public expenditure on agricultural R&D in India has declined significantly, from a peak of 0.87% of agricultural GDP in 2010–11 to just 0.60% by 2020–21. Approximately 80% of R&D funding is allocated to research, including education, while the remaining 20% supports extension activities. However, the distribution of these funds is highly skewed. Crops receive 83% of the research budget and 92% of extension funding, whereas the cattle sector, contributing nearly one-third of agricultural GDP, receives only 10.2% of research funding and 6.2% for extension. This imbalance highlights the need for more equitable allocation of resources to address the broader agricultural ecosystem. Following a peak of 0.87% in 2010–11, public spending on agricultural R&D has markedly decreased to 0.60%

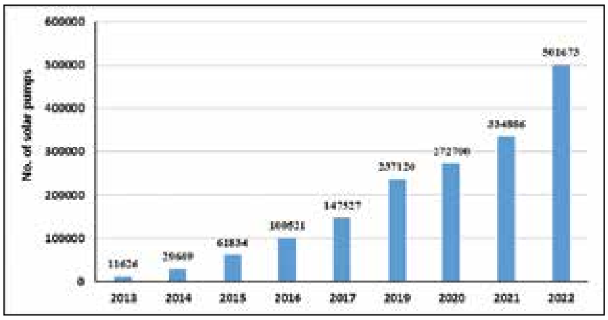




Payoff to spending on agricultural R&D



Incremental area under micro-irrigation

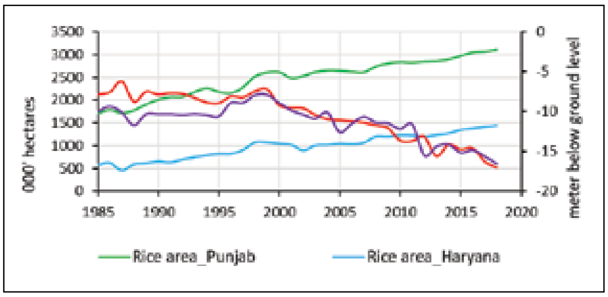


Trend in solar pumps installation

by 2020–21. The 80% of all R&D spending goes towards research, including education and with the remaining portion going towards extension activities. Moreover, the distribution of R&D expenditures across agricultural subsectors is highly disproportionate, with crops receiving 83% of the research and 92% of the extension resources. On the other hand, the cattle industry, which accounts for around one-third of the agricultural GDP, only receives a disproportionately tiny percentage of funding–10.2% of research and 6.2% of extension. Nonetheless, agricultural R&D has proven to be highly productive. For every rupee spent on agricultural research, the payoff is an impressive ₹ 13.85, while extension services generate a return of ₹ 7.40 per rupee invested. Animal science research is almost twice as productive as crop science research (₹ 20.81 vs ₹11.69). However, the reverse holds for extension spending. India's investment in agricultural R&D is significantly lower than the global average, which raises concerns given the pressing challenges and opportunities in agriculture. Enhanced spending on agricultural research is crucial to address these challenges and maximize economic returns. Additionally, the uneven allocation of resources among subsectors highlights the need for greater investment in underfunded areas such as livestock, fisheries, and natural resources to ensure balanced and sustainable agricultural development.

Economic and environmental benefits of solar-power and micro-irrigation: The Government of India has implemented two distinct schemes to address groundwater and energy challenges: the Per Drop More Crop (PDMC) component of the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) for micro-irrigation, and the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana (PM-KUSUM) for solar pumps. While these technologies have potential synergies, their adoption remains unaligned. Micro-irrigation has expanded rapidly since 2010, covering 12.95% of irrigated areas by 2023, but adoption is concentrated in states like Karnataka, Rajasthan, Maharashtra, Andhra Pradesh, Gujarat, and Tamil Nadu, which account for 79% of the total micro-irrigated area. In contrast, states like Uttar Pradesh and Punjab report less than 2% adoption. Solar pump usage has also grown, comprising 2.33% of total groundwater extraction devices by 2022, with high adoption in Chhattisgarh, Rajasthan, Maharashtra, Haryana, and Uttar Pradesh. However, states with high micro-irrigation adoption, such as Karnataka, lag in solar pump uptake, while states like Chhattisgarh lead in solar pumps but underperform in micro-irrigation. Integrating these technologies could significantly enhance water and energy efficiency, boost crop yields, and lower CO_2 emissions. Full utilization of solar-powered micro-irrigation systems could save 65 billion cubic meters of groundwater and reduce carbon emissions by 45 million tonnes annually. However, integration challenges persist, requiring restructured institutional frameworks, tailored system designs, innovative financing, and strategic implementation to unlock their full potential for Indian agriculture.

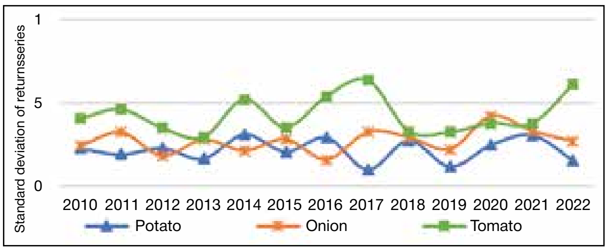
Policy convergence for groundwater management: In 2009, Punjab and Haryana implemented regulations to curb groundwater depletion by aligning paddy sowing with the monsoon onset. Despite initial success, these measures failed to halt groundwater decline, with both states recording a drop of over 4 m. Several factors undermined the initiative: heavily subsidized electricity for irrigation, farmers' reluctance to adopt short-duration paddy varieties due to yield concerns, and assured procurement of paddy at minimum support prices. Consequently, paddy cultivation expanded, covering



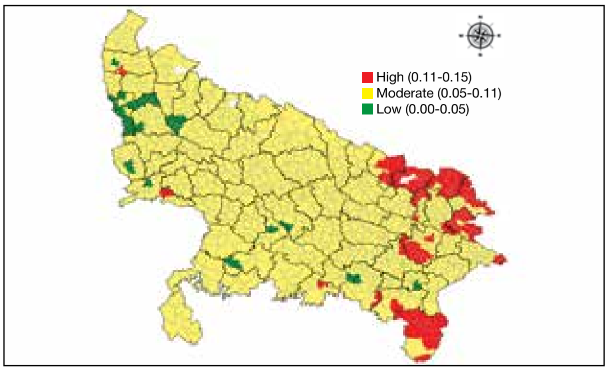
Trend in paddy area vs groundwater level

88% of Punjab's and 52% of Haryana's *kharif*-cropped areas by 2021–22, a 6% increase since the regulations' introduction. To address this issue, an integrated approach is critical, encompassing the proper implementation of existing legislation, rationalization or repurposing of electricity subsidies, revitalizing canal irrigation systems, and adoption of water-saving technologies, like tensiometers, laser-land levelling, and direct seeding of rice. Monetizing ecosystem services through initiatives such as the Green Credit Scheme can incentivize the adoption of sustainable practices. Crop diversification is the most desirable strategy for sustainability of natural resources including land. However, crop planning based on resource endowments is a necessary but insufficient condition, as few crops, aside from fruits and vegetables, can generate the same profit as paddy in both states. Introducing new crops in place of paddy implies policy support in the form of compensation for the revenue foregone from paddy cultivation.

Volatility in vegetable prices: Vegetable prices are more volatile than those of other commodities, which can arise due to multiple factors such as seasonality in production, variability in precipitation, pest infestations, inefficient supply chains, and demand-supply conditions. The unpredictability of these factors creates challenges for both producers and consumers. For instance, unanticipated extreme climatic events such as droughts or floods can significantly impact crop yields, resulting in sudden supply shortages and price spikes. A multifaceted approach is necessary to stabilize vegetable prices. Agricultural research should focus on developing varieties that can thrive in diverse climatic conditions, resist pests and diseases, and are suitable for processing. Additionally, investing in refrigerated transportation, cold storage facilities, and processing infrastructure to reduce post-harvest losses. These initiatives can also help secure fair prices for farmers' produce, reducing the likelihood of supply shortages contributing to price volatility.



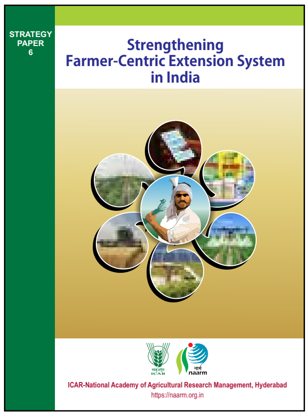
Vulnerability of agriculture to climate risks: Agriculture's vulnerability to climate change is a significant concern particularly at smaller geographical scales such as farms, villages, blocks, and districts. A comprehensive vulnerability index was developed and mapped for blocks in Uttar Pradesh focussing on four key dimensions: hazard, exposure, sensitivity, and adaptive capacity. The index incorporates 37 biophysical and socio-economic variables, which are relevant to policy offering a detailed understanding of the region's climate change vulnerability. Based on the index values, the majority of blocks in Uttar Pradesh face moderate vulnerability to climate risks. However, several areas in the eastern regions are particularly at risk, being highly vulnerable to these climate risks. This mapping of vulnerability at the granular scale serves as a valuable tool for policymakers and stakeholders to design and implement location-specific adaptation strategies. By identifying areas of high vulnerability, resources and efforts can be more effectively targeted to mitigate the adverse effects of climate change on agriculture and agriculture-based livelihoods.

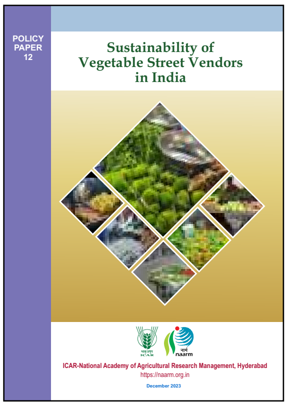


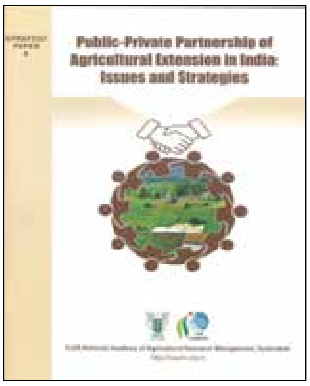
Climate - induced risk at block level in Uttar Pradesh

Research and Policy Advocacy (ICAR-NAARM, Hyderabad)

As part of its 'Think-Tank Policy' mandate, the ICAR-NAARM engaged in research driven policy advocacy in the critical areas of agriculture in India, such as strengthening farmer-centric extension system, enhancing agri-infrastructure and agri-business development through Public-Private Partnerships (PPPs), sustainability of vegetable street vendors, building organized sheep and goat meat sector, mainstreaming farmer's innovations for sustainable agriculture. Since October 2023, 43 research papers, 13 book chapters, 7 popular articles, 7 books, 3 success stories and 6 bulletins were published and also three copy rights were filed and registered.







Statistical Designs for Agriculture (ICAR-IASRI, New Delhi)

Estimation of unbiased variance in dual frame Surveys: Dual frame (DF) surveys utilize two frames to cover an entire population, often combining a comprehensive but costly frame with a more accessible yet incomplete alternative. Estimating unbiased variance in DF surveys is more complex than in single-frame surveys due to the need to account for population variances across distinct, often unknown domains. To address this challenge, the 'Post-stratified Rescaling Bootstrap with Unknown Domain Size (PstRUBD)' method was developed for variance estimation of the dual frame population total estimator. Simulation analysis demonstrates that PstRUBD provides unbiased variance estimates and outperforms standard bootstrap methods.

Geographically Weighted Spatially Integrated (GWSI) estimator: Large-scale surveys face challenges such as rising costs, increasing non-response rates, demand for detailed statistics, and the need for timely estimates. To address these issues, a framework for integrating data from multiple surveys has been developed, focusing on spatial non-stationarity, where variable-covariate relationships differ across locations. This framework introduces the Geographically Weighted Spatially Integrated (GWSI) estimator, which combines data from two independent surveys using spatial information to estimate finite population totals. Spatial simulations demonstrate that the GWSI estimator outperforms traditional design-based estimators across various spatial populations. Additionally, a Spatial Proportionate Bootstrap (SPB) method has been developed for accurate variance estimation of the GWSI estimator.

Resolvable Dichotomized Split-Set Partially Balanced Incomplete Block Designs: Resolvable incomplete block designs are useful for multi-site trials. In these designs, there is a need for efficient, resource-saving experimental setups. To address this, Dichotomized Split-Set (DiSS) association scheme, a four-associate class association scheme designed specifically for $v=2(p-1)$ treatments have been introduced. Based on this association scheme, a method for constructing Partially Balanced Incomplete Block (PBIB) designs have been developed. The proposed designs are cost effective in terms of resources, as they require lesser replications. The efficiency factors for these designs, compared to an orthogonal block design, are found to be quite high.

Generation of designs for Semi Latin Rectangles: Semi-Latin rectangles are the generalization of Semi-Latin square which are useful for situations when the number of levels of both the nuisance factors (factors of heterogeneity) are not same. A Semi-Latin rectangle can be defined as a row-column design in which (i) each row-column intersection has the same size, say k where $k > 1$, (ii) every treatment appears the same number of times in each row, and (iii) every treatment appears the same number of times in each column. Balanced SLR (BSLR) can be defined as a subclass of SLR that exhibit an additional property of balance, where no two distinct pairs of treatments differ in their concurrences. A partially balanced SLR (PBSLR) exhibits all the property of BSLR except each pair of distinct treatments are not appearing constant number of times in the design. To provide a platform for quick generation of BSLR and PBSLR, with parametric range $2 \le k \le 4$ and $k+1 \le v \le 20$ (k denotes cell size and v denotes number of treatments), $h, p > 1$, where h and p denote the number of rows and number of columns respectively, a web application has been developed and made available at https://drs.icar.gov.in/SLR/index.html.

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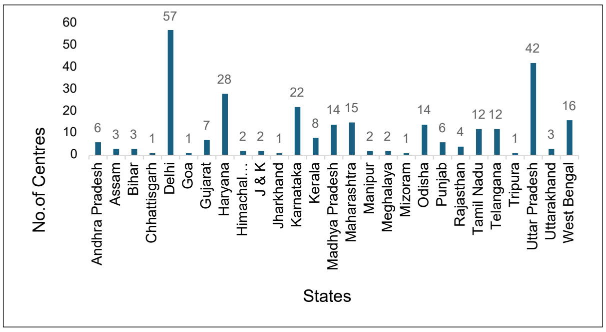
14.
Basic and Strategic Research

Under NASF, 28 new projects were approved on cutting-edge science related to crop health, nano-micro matrices, genome sequencing, point-of-care diagnostics, robotics, bio-formulations, agricultural innovation indices, AI-enabled weather and marketing systems, multimedia pedagogy, and agripreneurship. About 98.9% of the projects are multi-institutional. Additionally, 666 pre-proposals for Call XI in six strategic areas were received. Several agricultural innovations in crop breeding, sensor technologies, and farming systems for improving productivity, sustainability, and resilience were achieved under on-going projects. Genome editing technologies like CRISPR-Cas9 were employed to create rice mutants with enhanced drought, salt tolerance, and improved yield, such as the ckx2 mutant in Samba Mahsuri, which showed a significant grain yield increase. In pest management, sensors were developed to monitor crop health by detecting volatile organic compounds (VOCs) in infested crops and using colorimetric and resistive sensors for real-time monitoring. In crop breeding, a pearl millet genome-wide association studies (GWAS) panel revealed key SNPs linked to blast resistance, while GWAS in finger millet and maize identified markers for traits like seed longevity, vigour, and low pH tolerance. Advances in metabolomics enabled non-invasive sensors for early disease detection, such as for scab in apple trees. Additionally, integrated farming systems, including hydroponic and aquaponic setups, were developed to optimize resource use in greenhouse environments. Smart farming technologies, including AI-based decision support systems, solar-powered machinery for small farms, and unmanned robotic ground vehicles for agrochemical application, are paving the way for precision agriculture. These innovations, alongside improvements in livestock breeding and antimicrobial resistance detection, offer promising solutions for sustainable and efficient agricultural practices. NASF projects led to 90 research publications in reputed journals, in addition, seven patents filed/ granted, one copyright, one design registered and development of 12 technologies. Basic research undertaken in the schemes of ICAR National Professor/National Fellow/ Emeritus Professor/Emeritus Scientist also achieved significant advances, including identifying wheat accessions resistant to stripe and leaf rust, developing PCR markers for rice disease detection, and creating heat-tolerant maize hybrids. They also contributed to understanding plant genetics, antimicrobial resistance, and animal physiology through genome sequencing and novel therapeutic approaches.

NASF Funded Projects

The National Agricultural Science Fund (NASF) supports research in basic, strategic, and applied agricultural fields, including translational research, extramural grants, and international collaborations. Since 2006, NASF has funded 282 projects across various agricultural disciplines, with a total budget of ₹ 688.01 crore. These projects involve over 280 lead centres and 530 cooperating centres nationwide. NASF's pluralistic approach includes participation from ICAR (60%), SAUs (14%), CAU' (1%) and other organizations, reflecting its focus on priority agricultural research areas. The state-wise distribution of projects revealed that Delhi (20%), Uttar Pradesh (14.7%), and Haryana (9.8%) hosted most of the lead centres, highlighting the northern region as having the highest number of lead centres. Additionally, nine projects are being implemented in the North-East region.

The NASF projects have resulted in over 950 publications and 35 patents, while training over 1,200 SRFs, RAs, YPs, and others, and creating employment for skilled workers. Although equal opportunities are provided to both genders, only 7% of the 282 projects are led by women, reflecting a need for greater awareness and promotion among female researchers.



State-wise spread of project implementing lead centres of NASF

The NASF has supported new initiatives such as the Scientific Utilization through Research Augmentation-Prime Products/*Panchagavya* from Indigenous Cows

List of new projects approved under NASF

Title of project	Lead and cooperating centres	Budget (₹ in lakh)	Total cost (₹ in lakh)
Deployment of genetic and chemical options for the management of major biotic (*Orobanche* and *Alternaria*) stresses in Indian mustard*	ICAR-DRMR, Bharatpur ICAR-NIPB, New Delhi IPFT, Gurugram ICAR-RC NEH Region, Manipur	68.01 39.61 25.84 16.36	149.82
Enhancing abiotic stress tolerance in wheat and pearl millet: Insights from integrated epigenetic, physiological and molecular interventions	ICAR-NIPB, New Delhi RVSKV, Gwalior ICAR-IARI, New Delhi	49.54 43.80 30.76	124.11
Developing genomic selection strategy for accelerating breeding programme in perennial fruit crops grape, guava and mango	ICAR-NRCG, Pune ICAR-CISH, Lucknow ICAR-IARI, New Delhi PU, Chandigarh	35.94 33.36 34.36 21.27	124.94
Environmental and nutritional intervention to farm white leg shrimp, *Penaeus vannamei* in low saline water (LSW): A strategy for improving aquaculture production	ICAR-CIFE, Mumbai	50.39	50.399
Elucidation of molecular mechanism of captive reproduction *of Clarias dussumieri* and derive relevant molecular cues for successful induced spawning of male *Clarias magur*	ICAR-CIFE, Mumbai ICAR-CIFA, Bhubneswar	40.91 26.41	67.32
Bio-nano sulphur formulation of methanotrophs for decarbonisation, disease resistance and sustaining productivity in rice-oilseed cropping system	ICAR-NRRI, Cuttack ICAR-IARI, New Delhi ICAR-RCER, Patna	72.76 22.10 20.10	114.96
The development of a handheld sensor technology for non-destructive quality prediction of two economically important medicinal plants and the improvement of their quality	ICAR-DMAPR, Anand ICAR-IARI, New Delhi IIT, Roorkee	56.46 45.36 56.27	158.09
Development, standardization, and optimization of microbial and botanical pesticides and their formulations as efficient delivery systems for the management of agricultural, stored grain pests, nematodes and ticks parasites*	IPFT, Gurugram ICAR-IARI, New Delhi ICAR-IVRI, Izatnagar NU Medziphema Campus ICAR-NRRI, Cuttack	37.80 27.26 26.81 26.45 23.96	142.29
Estimation of chemical quality parameters of cinchona, jute and allied fibres and lac by fluorescence and NIR sensors and development of portable sensor instruments with thrust on fluorometry	JU, Kolkata ICAR-CRIJAF, Barrackpore ICAR-NISA, Ranchi DCOMP, Darjeeling	66.56 20.25 39.61 4.72	131.15
Natural grassland ecosystem monitoring system for peninsular and Trans Himalayan India to sustain pastoral communities	ICAR-IGFRI, Jhansi GBPNHE, Almora, (Ladakh RC) ICAR-IASRI, New Delhi ICAR-CCARI, Ela, Old Goa	48.20 36.62 10.50 10.90	106.22
Development of infectious clone, point-of-care diagnostics and transcriptome profiling for apple (*Malus domestica*) exhibiting mosaic disease associated with apple necrotic mosaic virus in north-western Himalayan region of India	ICAR-CITH, Srinagar ICAR-IARI, New Delhi Dr. YSPUH&F, Nauni	37.49 33.44 17.74	88.69
Development and evaluation of robotic harvester for grape bunches	ICAR-CIAE, RS, Coimbatore ICAR- NRCG, Pune	59.21 21.11	80.32
Development of novel strategy for the detection and tackling of Antimicrobial resistant (AMR) mastitis pathogens in dairy animals and environment using nanotechnology	ICAR-NDRI, Karnal WBUAFS, Kolkata	52.72 29.53	82.25
Expanding breeding window of IMC (*Labeo catla*) for year-round seed availability	ICAR-CIFA, Bhubaneswar KN University, Asansol	43.56 30.95	74.51
Development of Taluka scale precise crop yield prediction application for selected districts of Gujarat using remote sensing, AI and machine learning	JAU, Junagadh AAU, Anand ICAR-IISWC, Vasad	36.04 22.88 16.26	75.19
Point of care nanobiosensors for antibiotic residue detection in fish	ICAR-CIFRI, Barrackpore C-DAC, Kolkata	53.36 24.79	78.15
In-vitro production of oocyte- and spermatozoa-like cells from pluripotent stem cells of farm animals	ICAR-NDRI, Karnal ICAR-CIRB, Hisar	49.00 39.86	88.86
Deciphering agricultural soil microbiomes for sustainable management of lignocellulosic wastes and bioremediation of chlorpyrifos (dt50) contaminated sites	VNMKV, Prabhani ICAR-IARI, New Delhi IPFT, Gurugram	38.34 32.66 80.30	151.32
Integrating whole genome resequencing, transcriptome sequencing and genome wide association analysis for allele mining of yield and quality traits in black pepper and cardamom	ICAR-IISR, Kozhikode KAU-CRS, Idukki ICAR-ICAR-IASRI, New Delhi	73.97 18.21 15.61	107.79
Deciphering the genetic basis of lower susceptibility of indigenous cattle to bovine anaplasmosis	ICAR-NBAGR, Karnal SKUAST, Jammu	45.06 26.10	71.16

(Continued)

(Concluded)

Title of project	Lead and cooperating centres	Budget (₹ in lakh)	Total cost (₹ in lakh)
Artificial intelligence enabled biotic and abiotic stress detection and advisory mobile application for crops	ICAR-IASRI, New Delhi	40.82	97.40
	ICAR-CITH, Srinagar	18.86	
	ICAR- IIWBR, Karnal	18.86	
	ICAR- IIPR, Kanpur	18.860	
Effects of abiotic and biotic factors on secondary metabolite profiles of *Rauvolfia serpentina* and *Tribulus terrestris*: Optimizing cultivation strategies in different agro climatic regions of India	CSIR- NBRI, Lucknow	54.16	125.22
	CSIR-CIMAP, RC, Bengaluru	43.51	
	ICAR- DMAPR, Anand	27.54	
Comparative study on carbon dynamics and functional rhizosphere microbial biomass of agroforestry systems in dry-and wet- tropical climatic situations	ICAR-CARI, Jhansi	57.72	96.48
	Doon University, Dehradun	38.76	
Development of multimedia-based pedagogy models and modules for agricultural extension and education	ICAR-IARI, New Delhi	25.36	41.22
	ICAR-ATARI, Zone-I, Ludhiana	15.86	
Developing Indices for agricultural innovation ecosystem to sustain the growth paradigms of agricultural systems	RPCAU, Pusa, Samastipur	24.86	42.72
	ICAR-DOGR, Pune	17.86	
Potential of crop residues in NEH region – A circular economy perspective for sustainable livelihood*	CAU, Imphal	24.60	56.18
	ICAR-NINFET, Kolkata	15.31	
	AAU, Johrat	16.27	
Strengthening the agri-horticulture systems for the socio-economic development of the rural communities in the Western Himalayan ecosystem*	GBP-NIHE, Almora	33.52	47.54
	ICAR-VPKAS, Almora	14.02	
Developing simulation model of technology diffusion (TechSIM), adoption and impact for forecasting using techno-socio-psycho-economic-ecological factors*	ICAR – NRRI, Cuttack	39.08	100.00
	ICAR- RCER, Patna	11.95	
	VBU, Sriniketan	12.53	
	CAU Imphal, Barapani, Umiam	11.95	
	ICAR-RC for NEH Region, Wokha	11.95	
	BAU, Ranchi	12.53	

** Approved under NASF projects for tribal and hilly regions (cf Chapter 18)*

(SUTRA-PIC) and Extra Mural Research (EMR), along with the development of the CRISPR Crop Network for improving stress tolerance, nutritional quality, and crop yield. It has funded four SUTRA projects, 11 EMR projects, and 12 CRISPR-related projects. Through its funding, NASF contributes to SDGs and NDPs, strengthening the agricultural research ecosystem and advancing sustainable development goals.

During the reporting period, NASF approved 28 new projects. Notably, 86 out of 87 active NASF projects are multi-institutional. NASF also called for pre-proposals for Call XI in six strategic areas, receiving 666 pre-proposals, which are now being evaluated for full project proposals.

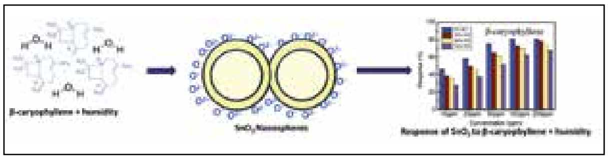
Salient achievements of NASF projects

During the reporting period, NASF led to 90 research publications in reputed journals, in addition, seven patents filed/granted, one copyright, one design registered and development of 12 technologies were achieved. The research highlights of some selected projects are as follows:

RNA guided genome editing (CRISPR-Cas9/ Cpf1) to improve stress tolerance in rice: Genome editing technology (CRISPR-Cas9) was used to create loss of function mutants of the *drought and salt tolerance* and *dense and erect panicle* 1(*DEP1*) genes in rice cultivar MTU 1010, *Cytokinin oxidase 2* (*ckx2*) gene in rice cultivar Samba Mahsuri (BPT 5204) and *ideal plant architecture 1* (*IPA1*) editing in rice cultivar Swarna. Two *dst* mutants with drought and salt tolerance in MTU 1010, and one *ckx2* mutant with enhanced grain yield in Samba Mahsuri were identified. The *ckx2* mutant showed more than 2-fold increase in grain number, and provide 20–35% more grain yield as compared with Samba Mahsuri in the AVT-I and AVT-II field trials.

Samba Mahsuri (BPT 5204) and *cytokinin oxidase 2* (*ckx2*) gene mutant in Samba Mahsuri (GeD 7-26-3)

Development of fluorescent and resistive sensors for monitoring the crop health: Analysis of Volatile Organic Compounds (VOCs) in tomatoes from healthy and *Tuta absoluta*-infested plants showed that the infestation significantly altered the VOC profile, increasing compounds like β-Phellandrene and β-Caryophyllene. A two-port resistive sensor, made by drop-casting SnO_2 nanospheres, was developed to detect β-Caryophyllene in concentrations of 10-200 ppm at 250°C. Additionally, a tetrazine-based colorimetric sensor was created for rapid, visual detection of β-Caryophyllene, offering a valuable tool for real-time VOC monitoring.

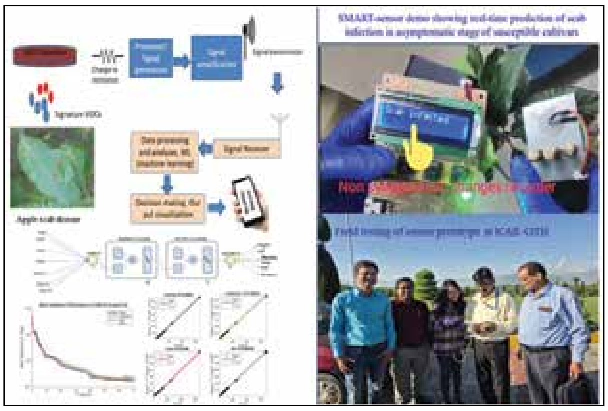

Response of SnO_2 to β-caryophyllene

Development of portable fluorescence and near-infrared sensors: Portable fluorescence and near-infrared (NIR) spectroscopy-based sensors were developed for rapid, non-destructive estimation of chemical quality parameters in cinchona, jute, and allied fibers. Miniaturized sensor designs were tested on cinchona samples. Chemometric models using NIR and fluorescence data effectively estimated cinchona alkaloids (total alkaloids, quinine, quinidine) and lignocellulose components (lignin, cellulose, hemicelluloses) in jute and allied fibers.

Transcriptome sequencing and genome wide association in cardamom: A high-quality chromosome-scale reference genome for the small cardamom variety Appangala 1 was developed using whole genome sequencing. Phenotyping of key agronomic traits, yield components, capsule size, and alpha terpinyl acetate content successfully identified superior varieties with improved yield and quality traits.

Diversity among the association mapping panel genotypes for capsule traits (colour, shape, size) in cardamom

Metabolite-based non-invasive sensor for early scab-disease diagnosis in apple: A non-destructive evaluation of scab tolerance in resistant (cv. Prima) and susceptible (cv. Oregon Spur) apple cultivars was conducted using leaf VOC compositions. The VOC profiles revealed 16 compounds, with cis-3-hexenyl acetate (3HA) identified as a biomarker. A hand-held, non-invasive sensor was developed to predict scab disease in apple plants before symptoms appear, achieving an accuracy of 76% in predicting scab in apple orchards.

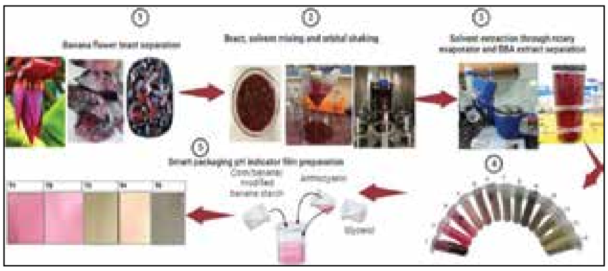


Foodomics study for food authentication and exploration of nutraceutical potential: Samples of grapes (104), apples (29), and pomegranates (20) were screened for non-targeted pesticide metabolites. Twenty-nine pesticides were identified, with carbofuran 3-keto and acetachlor metabolites detected in organic grapes. Thiacloprid, diflubenzuron, chlorantraniliprole, and acetamiprid were found in imported apples. Additionally, a comprehensive NIR spectral database was created for authentic shrimp and squid specimens. Machine learning algorithms were trained using these spectra, enabling a portable NIR device to confirm seafood species identity in a non-destructive manner, potentially addressing seafood mislabeling on-site.

Sensor based integrated vertical farming for horticultural crops and aquaponic system: Integrated hydroponic and recirculating aquaponic systems were developed for greenhouse farming, combining soilless cultivation with water recirculation to enhance nutrient recycling and reduce water usage for basil, mint, and pakchoi. The automated system, equipped with sensors to monitor critical parameters such as pH, EC, dissolved oxygen, water temperature, and nutrient levels, improves productivity and reduces manual intervention.

Greenhouse aquaponics system with basil, mint and pak choi

Development of smart foods, bio-composites, green packaging and bio-energy from agro residues: A banana flower bract anthocyanin-based pH-sensitive biofilm indicator was developed using banana starch and derivatives, serving as a visual freshness indicator for products like chicken meat and pH-sensitive horticultural items. A banana pseudostem fiber combing equipment was also created, featuring a roller assembly, frame, outlet chute, and motor mount with a power source. Additionally, thermoplastic starch sheets were prepared from cassava starch-banana fiber and cassava starch-beeswax composites.



pH sensitive intelligent packaging film using banana bract anthocyanin and banana starch

AI-enabled farm, weather and market information-based decision support system (FARWM-DS): A weather forecasting expert system was developed for 2024–25 using CMIP6 data, providing advisories for normal, above normal, and below normal conditions for cotton, groundnut, tomato, and red gram. A mapping tool was created to identify clusters of 60 farmers per crop. A structured schedule for benchmark data collection was pre-tested, resulting in data from 240 farmers across six villages for cotton, groundnut, and tomato, with red gram data collection ongoing. The first version of AI-based algorithms for weather advisories is ready, and a database management system (DBMS) is under development.

Solar powered prime mover with multi-tool attachments for small farm holdings: A solar-powered prime mover with a solar charging cart and multi-tool attachments was developed to support sowing, spraying, and weeding operations for small farm holdings. The solar charging cart not only charges the battery pack but also powers a DC pump and other AC loads up to 2 hp capacity. In addition to supporting these three operations, the solar power from the cart is also utilized for other essential farm equipment, including a chaff cutter, mini-dhal mill, milking machine, and groundnut stripper.

Unmanned robotic ground vehicle for spray application of agrochemicals: A lightweight, high-clearance chassis and mounting frames were designed and fabricated to support all components of the unmanned robotic ground vehicle (UGV). The vehicle's four wheels are steered via an electromechanical mechanism, with electric linear actuators enabling a 110° rotational angle through push or pull action. The vehicle operates with a GPS-guided auto-navigation system, where signals from the GPS unit and base station are processed by the core controller to manage the drive wheel, steering, and spraying boom controls. The algorithm for these systems has been integrated into the microcontroller programming. A mechatronically integrated spraying system was designed for targeted canopy spraying of agrochemicals on field crops, including potato, wheat, and chili.

A view of developed unmanned ground vehicle (UGV)

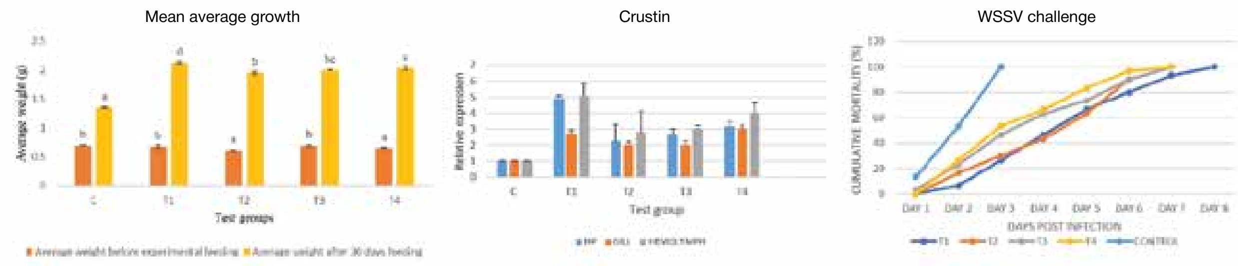
Semen characteristics, fertility parameters and performance of cloned bulls: Supplementation with MitoQ and melatonin antioxidants during oocyte and cloned embryo culture enhanced oocyte maturation and embryo production by reducing ROS and apoptosis. A total of 1,016 embryos were reconstructed, resulting in 154 blastocysts, with 55 embryos transferred to synchronized females (n=27), leading to three pregnancies. Semen quality and fertility of cloned buffalo bulls were similar to breeding bulls. Progeny from cloned bulls showed significant milk production improvements over their dams. Over 3,800 artificial inseminations using frozen semen from cloned bulls in Haryana achieved a 43% conception rate, with more than 800 healthy calves born.

Progeny born from semen of cloned bulls at Nuh district of Haryana

Development of nano-micro matrices for the delivery of bioactives, micronutrients and therapeutics: Curcuminoids were successfully encapsulated using a pH-driven method, stabilizing them with milk protein to form nanoparticles (80–95 nm), which were tested in milk and yogurt formulations. A probiotic consortium of *Lactobacillus paracasei* and *Kluyveromyces marxianus*, coated with tannic acid, Eudragit, and nanoliposomes containing taurine, folic acid, vitamin B12, D3, and iron, was encapsulated in a pectin core with a zinc protein shell. A technology for encapsulating *L. reuteri* and *L. salivarius* as porous spray-dried nano-microfibers was developed, achieving 89% viability and improving gut health in neonatal calves. Toxicity studies on the antibacterial nanovehicle, Udder Targeted Dendrimer-based Nanovehicle for Antibacterial Delivery (UTDNAD), showed no adverse effects, while biodistribution studies of bovine milk exosomes indicated significant accumulation in gut and lung tissues, with buffalo milk exosomes enhancing paclitaxel efficacy against breast cancer cells.

Detection and tackling of antimicrobial resistant (AMR) mastitis pathogens in dairy animals: A strip-based assay was developed for detecting *E. coli* and *Listeria monocytogenes*. The paper strip sensor was tested with various *E. coli* isolates, including *E. coli* ATCC 25922, KF 7831, KF 7994, and CYK-46, using ESBL antibiotic discs. *E. coli* ATCC 25922 was sensitive, while KF 7831 and CYK-46 were resistant to ESBL antibiotics, and KF 7994 showed intermediate resistance, with detection achieved in 8 h. The assay was also tested with different *L. monocytogenes* strains, including ATCC 19115, ATCC 19118, ATCC 15313, MTCC 1143, and BAA 751. *L. monocytogenes* ATCC 19115 was antimicrobial-resistant, while the others were sensitive, with detection completed in 10 h.

Disease free health certification in finfish and high health shrimp: Monoclonal antibodies (MAbs) for health certification in finfish were developed. Serum



Shrimp growth in different treatments | Immunegene expression | Challenge against WSSV

immunoglobulins (sIgs) from three Indian Major Carps (IMCs), *Labeo rohita*, *Catla catla*, and *Cirrhinus mrigala,* showed bands corresponding to heavy (~80 kDa) and light (~27 kDa) chains. These MAbs offer promise for immunoassays to detect pathogen-specific antibodies in these carps. For sustainable aquaculture, a combination of probiotic (*Bacillus subtilis*) and prebiotic (inulin) was used to develop high-health Pacific white shrimp, showing enhanced growth, improved survival rates, and higher immune gene expression. This combination significantly boosts shrimp growth and health, highlighting its potential as an effective immune modulator.

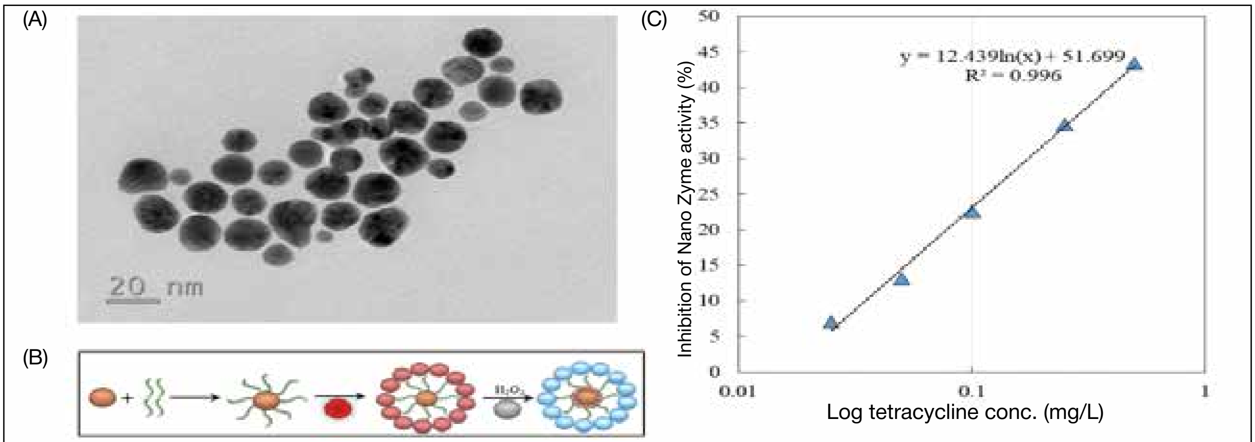
Point of care nanobiosensors for antibiotic residue detection in fish: A colorimetric aptasensor was developed for detecting the antibiotic tetracycline in water, aimed at treating diseases in cultured fish species. The sensing mechanism relies on the inhibition of the peroxidase-mimic catalytic activity of gold nanoparticles (AuNPs) through aptamer-induced tetracycline adsorption, producing a colorimetric response. The sensor is insensitive to tetracycline metabolites (e.g. 4-epitetracycline) and other non-target antibiotics (e.g. oxytetracycline, trimethoprim, ampicillin, erythromycin). This analytical method is simple, using only gold nanoparticles and a tetracycline-specific aptamer.

Pork marketing chains in north-east India for sustainable livelihood of tribal women: Three clusters were established to enhance skills in scientific pig production, biosecurity measures, waste management, and entrepreneurial alternatives. Four knowledge products were developed: vegetable waste-based silage for pig feed, pork processing, value addition for women entrepreneurship, and pig farming aspects like housing, breeding, and marketing in Nagaland. A business plan for small and medium pig farmers was also created for the commercialization of pig farming. A multi-layered innovative pathway was designed for short, medium, and long-term goals. A 'Model-Village Approach' action plan was formulated, with a multidimensional methodology that can be replicated for a sustainable livelihood framework.

Need based technology delivery model through farmers' producer organization: Technology delivery models for seed production, safe food production, vegetable cultivation, and natural resource management were developed for the eastern region of India. Five new FPOs were established, and nine existing FPOs were strengthened through targeted training and linkages with other organizations. A social network for farmer-to-farmer communication was created, improving the dissemination of technological knowledge. Additionally, a farmers' empowerment index, covering eight sub-categories, was developed to assess changes in farmers' empowerment levels.

Research Achievements by ICAR National Professor/National Fellow/Emeritus Professor/Emeritus Scientist

Revisiting the epidemiology of *Puccinia* species on wheat accessions and identifying diverse sources of rust resistance: To identify adult plant resistance



TEM images of L-tyrosine capped gold nanoparticles (A) and Aptasensor-mediated color inhibition in presence of tetracycline (B) and Corresponding calibration curve (C)

Resistance in wheat to stripe rust

(APR), 176 wheat accessions were evaluated for stripe rust (*Puccinia striiformis*) resistance under natural field conditions and controlled polyhouse environments, using pathotypes 110S119, 238S119, and 110S84. Twenty-eight lines, initially susceptible to some pathotypes at the seedling stage, showed significant resistance at the adult plant stage. These included Barani 83, Bahiltai, C 273, Fakhre Sahi, FSD 2008, Har 627, Har 1018, Har 2505, Hypuno, Kashmir15, Mulgora, Shield, Suneo, Sunland, Tilotma, V04189, Vijaya, Walfag 2001, HD 3086, HW 5514, HW 4701-2, Motia, HD 2009, HS 86, HUW 12, NP 846, UP301, and Yakora. Gene matching revealed three resistance patterns (*Yr2, YrA, and Yr9*) in 111 of the lines.

To assess seedling (all-time) resistance for leaf rust, the 176 lines were screened against 26 virulent and predominant pathotypes of *P. triticina* under controlled light and temperature conditions in the greenhouse. These pathotypes were selected for their diverse virulence profiles. The study was repeated to confirm the consistency of infection. Twenty-three accessions, namely, Both, Dhaulagiri, Ega Wills, ETBW 523, Giles, HP 1731, Lang, Mulgora, PBW 550, Quain#2, Shield, Suneco, Sunland, Sungard, DARE*6/3/Ag3/Kite, HW 5270, HW 2436-2, HW 5503, HW 5514, HW 4704, HW 4701-1, Vijay, and Bijaga Red—demonstrated all-time resistance against the 26 pathotypes.

Resistance in wheat to leaf rust

Rust on grasses

To study the perennation of wheat rusts, off-season surveys were conducted in areas where stripe rust and leaf rust frequently appear on wheat. Surveys were carried out in the Yamuna Nagar, Karnal, and Panchkula regions of Haryana; Ropar and Mohali in Punjab; and Baddi, Ponta Sahib, Dhaulakuan, Hamirpur, Bilaspur, Una, and Kangra

Actinobacterial colonies (*top*); Pot culture evaluation of native actinobacteria for plant growth promotion (*bottom*) in Himachal Pradesh. One survey was conducted before wheat sowing, and another one month after sowing. A total of 295 rust samples were collected from grasses and other plants. However, none of these samples were able to infect susceptible wheat or barley stocks.

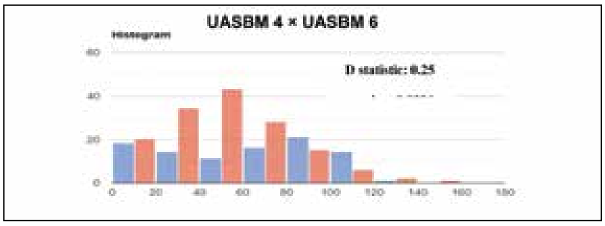
Actinomycetes diversity and their role in agriculture for green growth: Twenty-one Actinobacteria isolates were obtained from various ecosystems, including compost, cow dung, uncultivated soil, cowpea rhizosphere, and mangrove soil. These isolates, along with 29 from the Department of Agricultural Microbiology's repository at the College of Agriculture, Vellanikkara, were screened for direct and indirect plant growth-promoting activities and mutual compatibility. Selected promising isolates were then formulated into consortia and evaluated for their efficacy in promoting plant growth and controlling fungal diseases, using cowpea as the test crop.

Insights into reductive evolution and genome-based taxonomy of Phytoplasmas in brinjal and tomato: Surveys of brinjal fields at IARI, New Delhi, and Gorakhpur, Uttar Pradesh, revealed 5-12% disease incidence. Suspected phytoplasma-infected samples exhibiting little leaf, witches' broom, and stunting were collected for PCR analysis. Primer pairs P1/P7 and 3F/3R, P1/Tint and 3F/3R, and TUF-II-F1/TUF-II-F2/TUF-II-R1 yielded the best PCR amplification of phytoplasma DNA. Subsequent 16S rRNA gene sequence analysis showed 98-99% identity with the Brinjal Little Leaf Phytoplasma strain belonging to the 16SrVI-D subgroup.

Field surveys of tomato in mid-2024 in Andhra Pradesh (Tirupati and Annamayya districts) and Madhya Pradesh (Chhindwara) revealed high tomato big bud (TBB) disease incidence, with 2-3% and 32-100% phyllody symptoms observed in 'Heemsohna' and 'Sahoo' varieties, respectively. Malformed inflorescences and flowering buds, characteristic of TBB, were observed. PCR using universal phytoplasma nested primers (P1/Tint, R16F2n/R16R2, and 3Forward/3Reverse) amplified ~1.25 and ~1.3 kb fragments from all symptomatic samples from Andhra Pradesh. BLAST analysis of 16S rRNA gene sequences showed high identity with '*Ca. P. australiaticum*' and 'Ca. *P. trifolii*'. Virtual RFLP analysis confirmed these classifications, aligning with 16SrII-B and 16SrVI-D subgroups (similarity coefficient 1.00). Thus, TBB phytoplasma strains were classified as 'Ca. *P. australiaticum*' (16SrII-D) and 'Ca. *P. trifolii*' (16SrVI-D). The positive identified as BLL and TBB strains (16SrVI and 16SrII subgroup) were sent to Nx Gen Bio Life Sciences for whole genome sequence analysis. The data generation for BLL samples and QC data is in progress.

Pollen selection approach to develop reproductive stage heat-stress tolerant inbred lines and hybrids in maize: Fifty-two hybrids, developed using new heat-tolerant UASBM inbred lines (derived via pollen selection) and two testers (MAI 105 and LM 13), were evaluated under heat stress at the internationally recognized heat tolerance screening center, ARS, Bheemarayanagudi, alongside six checks (RCRMH 2, RCRMH 3, RCRMH 4, NK 6240, DKC 9133, and S 6668 Plus). Three hybrids significantly out-yielded the best commercial check. Further, 11 UASBM inbred lines were also evaluated for productivity and pollen fertility in an RCBD at ARS, Bheemarayanagudi. Quantitative traits, including seed yield, cob length/girth, number of cobs/kernels per row, were assessed. Pollen fertility was evaluated using pre-anthesis samples. Tolerant inbreds (UASBM 42 and UASBM 30) exhibited higher yield and pollen fertility, while susceptible inbreds (UASBM 4 and UASBM 14) showed lower performance. Heat stress significantly reduced internodal length and plant height, and even prevented flowering in UASBM 14.

Four F_2 populations from two crosses (UASBM 4 × UASBM 6 and UASBM 14 × UASBM 6), generated



Significant difference in the distribution of pollen selected and control F_2 Population of the cross UASB 4 x UASB 6.PS: Pollen selection (Red) and Control (Blue)

List of superior heat-tolerant maize hybrids identified

Testcross hybrid	increase (%) over the best check (RCRMH-3)
LM 13 × UASBM 23	26.10
LM 13 × UASBM 35	25.44
LM 13 × UASBM 10	22.02

List of superior maize hybrids identified under normal conditions

Hybrid	increase (%) over the best check (Penna 3422)
MAI 105 × UASBM 41	17.03
MAI 105 × UASBM 7	14.57
LM 13 × UASBM 10	11.72
MAI 105 × UASBM 43	11.58

Performance of contrasting inbred lines for seed yield and pollen fertility under heat stress

Response	Inbreds	Grain yield (g)	Pollen fertility (%)
Heat tolerant	UASBM 42	134.00	60.75
	UASBM 30	111.00	49.02
Heat susceptible	UASBM 4	6.33	44.94
	UASBM 14	47.33	34.35
CD @5%		126.68	-

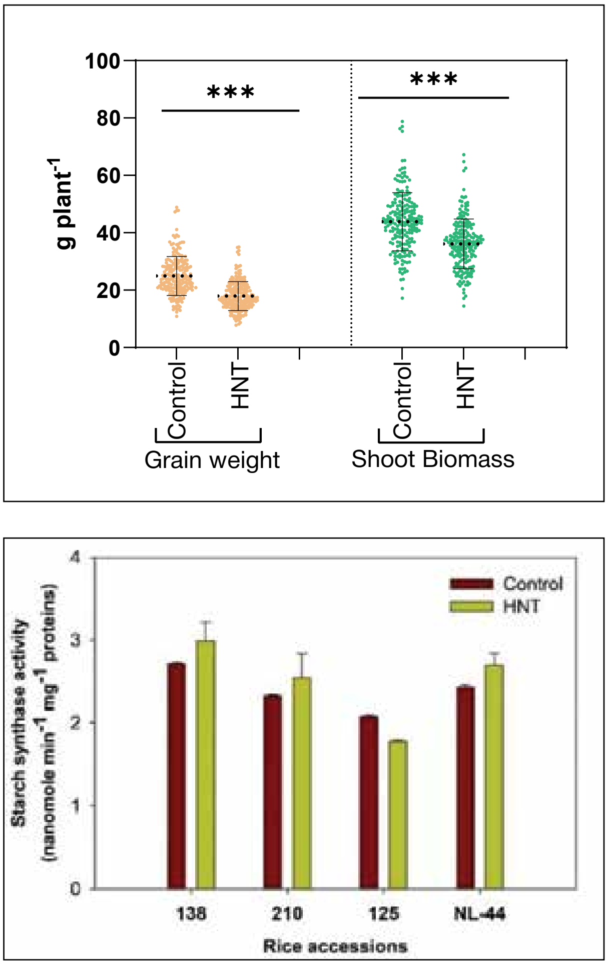
with (PS) and without (C) pollen selection for heat tolerance at the F_1 stage, were evaluated for heat tolerance at ARS, B'gudi during the 2023-24 summer. Evaluating quantitative traits, including seed yield per plant, revealed significant differences between PS and control F_2 populations in both crosses. Specifically, the Kolmogorov-Smirnov test showed a significant difference in the distribution of PS and control F_2 populations for the UASBM 4 × UASBM 6 cross. The PS population exhibited a positive skew, demonstrating the effectiveness of pollen selection in improving heat tolerance.

Sixty testcross hybrids produced using new UASBM inbred lines and two testers, MAI 105 and LM 13, were evaluated along with four checks (Penna 5422, Victoria 549, MAH 14-5, and MAH 15-84) under normal irrigated conditions at UAS, GKVK, Bengaluru. The testcross hybrids exhibited significant variation in quantitative traits such as seed yield per plant, cob length, number of cobs per row, cob girth, and number of kernels per row. Four hybrids showed significantly higher yield over the best commercial check hybrid. A large quantity of the identified superior hybrids is being produced during *kharif* season of 2024 for evaluation under heat stress environments again to confirm the performance of the hybrids.

Development and validation of PCR-based markers for detecting *Bipolaris oryzae* in rice: Brown-spot disease, caused by *Bipolaris oryzae*, is a growing threat to global rice production. A rapid PCR-based diagnostic assay was developed for monitoring the pathogen in rice fields. A specific marker, $BORA_{278}$, derived from a unique small-secreted protein gene (XM_007689836.1), was identified through comparative secretome analysis. This marker distinguishes *B. oryzae* from other *Bipolaris* species and rice fungal pathogens. Detection limits were 1 pg of DNA via conventional PCR and 10 fg via real-time PCR (qPCR). The assay enables early, reliable detection, even before symptom onset, facilitating efficient disease management.

Phenotyping and analysis of nocturnal respiration under high night temperature stress in rice: A study

PCR amplification with specific marker (ssp1BoRA_278) of *B. oryzae* using genomic DNAs of different isolates of *Bipolaris* spp. and other pathogens. M:100bp DNA Ladder (Genei); 1: *B. oryzae* (Bo-1); 2: *B. oryzae* (Bo-2); 3: *B. oryzae* (Bo-3); 4: B. oryzae (Bo-4); 5: *B. oryzae* (Bo-5); 6: *B. sorokiniana* (LB-24); 7: *B. sorokiniana* (BS-112); 8: *B.specifera* (LB-28); 9: *Exserohilum rostratum* (LB-30); 10: *Puccinia triticina* (77-5); 11: *Fusarium fujikuroi* (F250); 12: *Rhizoctonia solani* (TP-3); 13: negative control (SUW).



Box plot analysis for seed weight and shoot biomass and activity of starch biosynthetic enzymes in grains of contrasting rice accessions under HNT exposure

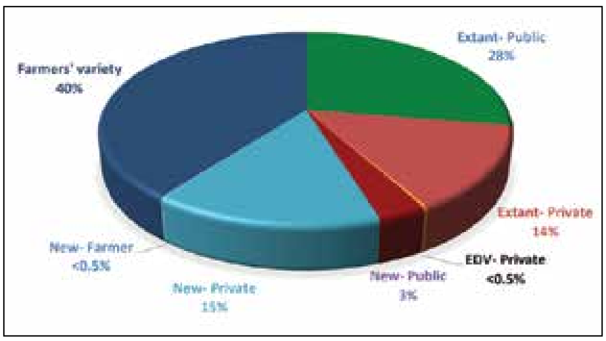
of 271 rice accessions was conducted to assess high night temperature (HNT, 29–32°C) stress responses at the Nanaji Deshmukh Plant Phenomics Center, IARI. Of these, 212 flowering accessions were analyzed for traits including shoot biomass, spikelet fertility, grain weight, and panicle yield. HNT caused significant reductions in spikelet fertility (12–48%) and panicle yield (5–42%), with variability across accessions. Based on panicle yield reductions, accessions were categorized as tolerant, moderately tolerant, or sensitive. Contrasting genotypes were further evaluated for reductions in non-structural carbohydrates and enzymatic activity. Tolerant genotypes exhibited higher AGPase and starch synthase activities in leaves and grains under HNT, maintaining grain yield despite stress. These findings highlight the potential of tolerant genotypes to sustain yield in warming climates.

Launch of Germplasm Supply Management System: A Germplasm Supply Management System (http://pgrinformatics.nbpgr.ernet.in/ds), developed under the ICAR-National Fellow project and hosted by ICAR-NBPGR, digitizes the germplasm supply process. It aims to make germplasm requisition and supply to researchers quick, transparent, trackable, and

paperless. The system was launched for public use on the 49th Foundation Day of ICAR-NBPGR by Dr Sanjay Kumar, Chairman of ASRB, and Dr. Himanshu Pathak, Secretary (DARE) and DG (ICAR), on 1 August 2024.

An Analysis on Ownership of Plant Genetic Resources Based on Registration under the PPVFR Act 2001

A study examined India's Protection of Plant Varieties and Farmers' Rights Act, 2001, designed to comply with WTO-TRIPS and promote agricultural innovation. Since 2009, 5,113 varieties across 84 crops have been registered, initially dominated by public sector institutions like ICAR, but increasingly involving farmers and private seed companies. This trend raises concerns about the potential privatization of public genetic resources. The study advocates for a state-led registration approach, emphasizing institutional mechanisms and welfare programmes to support farmers. It suggests using revenues from registered varieties to ensure equitable access, benefit-sharing, and agrobiodiversity conservation. Monitoring registration processes and intellectual property enforcement regionally is vital to prevent unwarranted privatization. Collaboration between public and private sectors, with active state government involvement, is highlighted as essential for innovation and biodiversity conservation. This strategy supports sustainable agricultural growth while aligning with global and national biodiversity goals.



Distribution of plant varieties registered across categories at PPV&FRA (2009–2022)

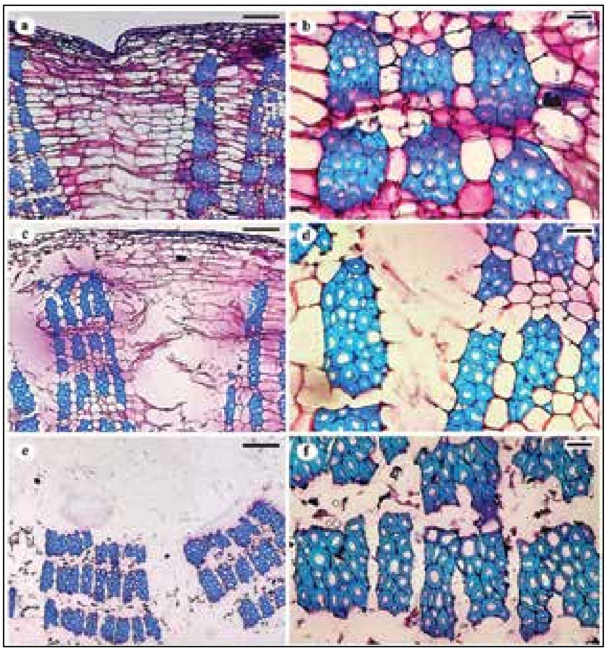
Aquaporin in domestic animals: Aquaporins (AQPs) are membrane proteins vital for regulating water and ion balance in tissues, found in nearly all organisms except thermophilic archaea and intracellular bacteria. In climate-adapted mammals, such as aquatic species and desert dwellers, maintaining water and electrolyte balance is crucial for survival and performance. AQP genes play a central role in these adaptations, which is important for understanding their structure and function. A study investigated the genomic locations, structural domains, and expression of AQPs in buffalo (*Bubalus bubalis*) and goats (*Capra hircus*). Mammals possess 13 AQP paralogs, arranged in two genomic clusters. In buffalo and goat, 13 AQP genes (AQP0–12) were cloned and characterized, with protein coding regions from 729 to 990 bps. Conserved NPA motifs and ar/R selectivity filters were found in all AQPs except AQP7, 11, and 12. Tissue-specific expressions were seen for AQP0, 2, 4, 5, 7, 9, and 12, while AQP1, 3, 8, and 11 were widespread. AQP10 was a pseudogene in artiodactyls. Evolutionary analysis revealed positive selection near key motifs in AQP0, 3, 6, 7, and 10, potentially altering their structure and function. This work provides a basis for future studies on AQPs' molecular mechanisms in various physiological conditions.

Interferon lambda in domestic animals: Type III interferon (IFN-λ) is an innate antiviral protein. In a study IFN-λ sequences and their receptors from 42 tetrapod species were retrieved and a computational evolutionary analysis to explore gene diversity was conducted. Copy number variation (CNV) of IFN-λ was assessed using qPCR in Indian cattle and buffalo. Tetrapods feature intron-containing IFN-λ genes, with reptiles and placental mammals having two loci, while birds, monotremes, and marsupials have one. Some placental mammals and amphibians possess multiple IFN-λ genes, including intron-less and intron-containing forms. Typically, placental mammals have 3–4 functional IFN-λ genes, some lacking signal peptides. IFN-λ in tetrapods forms three major clades, with mammalian IFN-λ4 appearing ancestral and showing syntenic conservation. Intron-less IFN-λ1 and both type III IFN receptors exhibit conserved synteny. Evolutionary analysis revealed purifying selection, ensuring the retention of biological function. The expansion of IFN-λ genes in amphibians and camels led to gene diversification. CNV likely results from gene duplication and conversion events. qPCR quantification showed multiple copies of IFN-λ3 and IFN-λ4 in buffalo (Murrah) and six cattle breeds (Sahiwal, Tharparkar, Kankrej, Red Sindhi, Jersey, and Holstein Friesian). These findings underscore the evolutionary diversity and functional importance of IFN-λ in tetrapods.

Mitigation of Anti-Microbial Resistance (AMR)

pathogen: Antimicrobial resistance (AMR), especially methicillin-resistant *Staphylococcus aureus* (MRSA), poses a significant threat to human, animal, and plant health globally. With limited novel drugs under development, the search for plant-based alternatives to combat antibiotic resistance has intensified. MRSA infections are difficult to treat due to rapidly evolving resistance mechanisms and protective biofilms. The antibacterial properties of 10 plant-derived ethanolic leaf extracts against MRSA were evaluated. The most effective extracts, ranked by zone of inhibition, were *Cannabis sativa* > *Syzygium cumini* > *Murraya koenigii* > *Eucalyptus* sp., while *Aloe barbadensis* and *Azadirachta indica* had minimal impact. *Mangifera indica*, *Curcuma longa*, *Tinospora cordifolia*, and *Carica papaya* showed no inhibitory effects, leading to the selection of *Cannabis* for further study. The minimum inhibitory concentration (MIC) of *Cannabis sativa* was 0.25 mg/mL, with 86% bacterial mortality. At sub-MIC (0.125 mg/mL), biofilm formation was reduced by 71%. Major cannabinoids identified were cannabidiol and delta-9-tetrahydrocannabinol (Δ9-THC), contributing to significant MRSA inhibition. Time-kill kinetics revealed bactericidal action at 4× MIC, reducing growth by 90%. SEM and Giemsa staining showed bacterial cell breakdown and increased alkaline phosphatase activity, suggesting cannabinoids could be a promising alternative to antibiotics for bovine biofilm-associated MRSA. To address the evolving resistance of MRSA, a novel chimeric endolysin, CHAPk-SH3bk, derived from LysK, was investigated for its antibacterial activity against planktonic and biofilm-forming MRSA. CHAPk-SH3bk bound to peptidoglycan with 14 hydrogen bonds. *In-vitro* assays showed a 2-log10 reduction in planktonic MRSA after 2 h. CHAPk and CHAPk-SH3bk exhibited bactericidal activity, reducing MRSA by approximately 4-log10 and 3.5-log10, respectively, after 24 h. Biofilm reduction assays showed CHAPk-SH3bk reduced 33% and 60% of hospital-associated ATCC®BAA-44™ and bovine-origin MRSA SA1 biofilms, respectively. CHAPk reduced 47% of preformed biofilm in bovine-origin MRSA SA1. This study highlights the potential of the novel chimeric endolysin CHAPk-SH3bk in reducing MRSA biofilms from both human and animal sources.

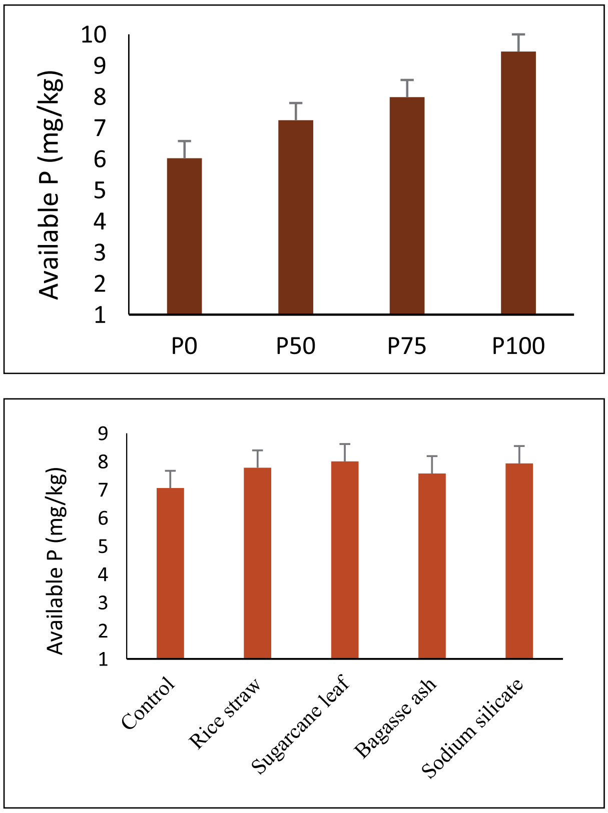
Microbial dynamics and pectin degradation during water retting of jute: A systematic study examined microbial colonization and pectin degradation during the water retting of jute (*Corchorus olitorius* cv. JRO 204), focusing on the breakdown of pectic materials between fibre bundles. The separation of bast fibres from the epidermis is mainly triggered by enzymatic pectin degradation, which acts as a binding agent. Controlled retting was conducted using the microbial consortium CRIJAF Sona, composed of *Bacillus safensis*, *B. velezensis* and *B. altitudinis*, with samples compared to naturally retted ponds. Observations on days 0, 7, and 10 showed significant pectin degradation, crucial



Light microscopy of TS of jute stems. Differential staining was performed with ruthenium red and toluidine blue 'O'. (a, b) Non-retted stems, intact cuticle and epidermis layer on day 0; (c, d) Mid-retted stems with distorted epidermis and parenchyma on day 7; (e, f) Retted fibre samples without any cementing material on day 10. Scale bar =100 µm (a, c, e) and 20 µm (b, d, f)

for fibre separation and quality. The study emphasizes that improper retting, either inadequate or excessive, affects fibre strength and quality. Using microscopic and biochemical methods, the research demonstrates that microbial pectin breakdown is key to fibre decohesion, offering insights for improving retting efficiency and fibre quality.

Enhancing available phosphorus in soils through silicon-enriched crop residues: Silicon (Si)-rich crop residues, including rice straw (RS), sugarcane leaf (SL), and sugarcane bagasse ash (BA), were assessed for their effectiveness in enhancing soil phosphorus (P) availability, with sodium silicate (SS) as a reference Si source. A greenhouse experiment was conducted using four soils from New Delhi, Pataudi, Coochbehar, and Samastipur. The soils varied in pH: New Delhi and Pataudi were alkaline alluvial, while Coochbehar and Samastipur were acidic alluvial and calcareous alluvial, respectively. Wheat was grown under a completely randomized design with two factors: phosphorus dose (0%, 50%, 75%, and 100% of the recommended rate) and Si sources (no Si, RS, SL, BA, and SS). Si was applied at 100 mg Si per kg of soil. Wheat yield and P uptake were recorded, and post-harvest available P was measured. Si application significantly increased available P in all soils except Coochbehar, with an average increase of ~11% in New Delhi, ~7% in Pataudi, and ~10% in Samastipur. Si from crop residues and SS improved wheat yield and P uptake across all soils. Both Si source and P dose significantly affected P uptake by wheat grain and straw. These results demonstrate the potential of Si-rich residues to enhance soil P availability, reducing the need



Effect of P fertilization and Si application through various sources on available P in soil of New Delhi [Error bar represent the least significant difference (LSD, P= 0.05) between the two treatments]

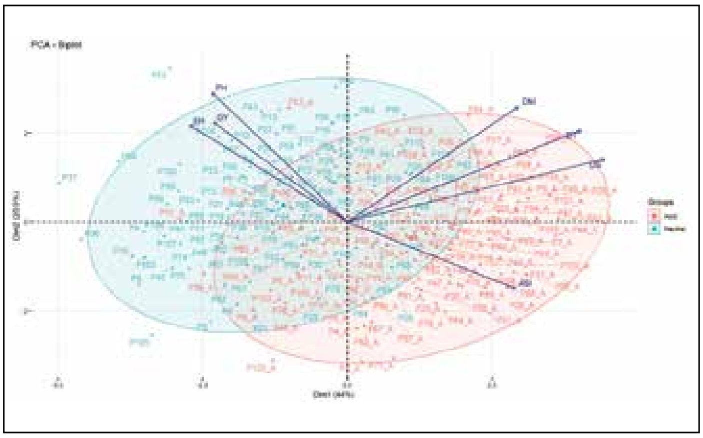
for high P fertilizer inputs in crop production.

Identification of key genes and molecular pathways regulating heat stress tolerance: To identify heat-responsive genes, leaf and root samples from two contrasting pearl millet inbreds, EGTB 1034 (heat-tolerant) and EGTB 1091 (heat-sensitive), were heat-treated and their genome-wide transcriptomes were analyzed. A total of 13,464 differentially expressed genes (DEGs) were identified, including many genes encoding ROS scavenging enzymes, WRKY, NAC, heat shock proteins (HSPs), and various transcription factors (TFs) involved in stress-response mechanisms. Comparative synteny analysis of HSPs and TFs revealed greater collinearity with pearl millet compared to proso millet, rice, sorghum, and maize. These genes show potential for accelerating the development of heat-tolerant pearl millet and similar crops.

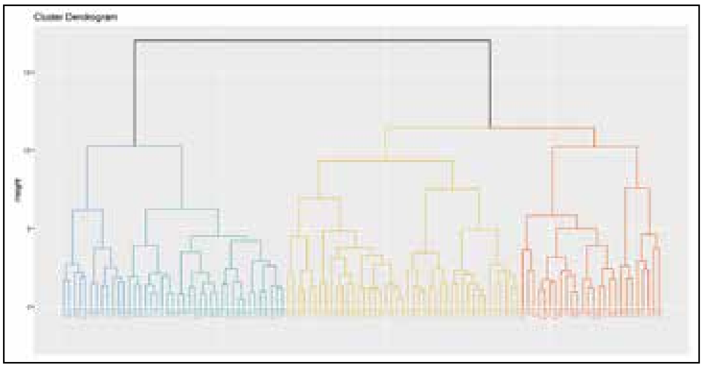
Novel SNPs linked to blast resistance genes identified in pearl millet: A pearl millet genome-wide association mapping (GWAS) panel was phenotyped for blast resistance against three distinct *M. grisea* isolates from Delhi, Gujarat, and Rajasthan, showing significant variability, with 16.7% of the inbreds exhibiting high resistance. GWAS models identified 68 significant SNPs linked to resistance, with hotspots on chromosomes 1, 2, and 6. These regions contain genes related to immune response, stress tolerance, signal transduction, transcription regulation, and pathogen defense. This study provides valuable insights into the genetic mechanisms of blast resistance, offering a foundation for marker-assisted breeding and gene-editing approaches.

Role of functional genes for seed vigour and longevity traits through GWAS: Seed longevity and seedling vigour are crucial for sustainable crop production amid climate change. A significant variation was identified in seedling vigour traits in the GWAS panel in finger millet (*Eleusine coracana*). GWAS model from 11,832 high-quality SNPs identified through Genotyping-by-Sequencing (GBS) approach produced 491 marker-trait associations (MTAs) for 27 seed longevity traits. A pleiotropic SNP, FM_SNP_9478 identified on chromosome 7B was associated with the traits GAA, GAAR, GIAA and GIAA. Functional annotation revealed *DET1* and *expansin-A2* influenced seed coat integrity, critical for germination and aging resilience. *Beta-amylase* and *acetyl-CoA carboxylase 2* were identified for seed metabolism and stress response. These insights lay the framework for targeted breeding efforts to improve seed quality and resilience under diverse production conditions.

Multivariate analysis and clustering of maize inbred lines: The performance and diversity of 110



Principal component analysis (PCA) biplot of maize genotypes under acidic and neutral soil conditions



Hierarchical cluster dendrogram of maize genotypes using euclidean distance (acid soil) maize inbred lines were evaluated under neutral (pH 6.8) and acidic (pH 4.6) soil conditions, aiming to identify genotypes with low soil pH tolerance. Statistical methods, including Mahalanobis distance and Tocher's clustering, were employed to evaluate diversity and cluster lines based on their performance. Under acidic conditions, results showed significant reductions in plant height (PH), ear height (EH), and grain yield, coupled with an increase in anthesis silking interval (ASI), indicating stress effect. Inbred lines P53, P37, P66 and P100 were identified as best performers, with P53 achieving the highest score, under low soil pH. Correlation analysis between traits and yield revealed weak associations, suggesting that multiple traits must be considered in breeding programmes. Clustering analysis revealed significant diversity, among the lines showing the trait variability. This comprehensive evaluation underscores the importance of specific inbred lines in breeding programmes targeting improved maize performance in low pH soil.

Whole genome sequencing of pig genome: Whole genome sequencing and chromosome-level assembly were successfully completed for two indigenous pig breeds, Ghungroo (INDIA_PIG_2100_GHOONGROO_09001) and Mali (INDIA_PIG_1900_MALI_09009),

as well as for two exotic breeds, Hampshire and Large White Yorkshire (LWY), previously available only at the scaffold level. The genomes, averaging 2.55 GB in size, consist of ~40% repetitive elements, distributed among class I retrotransposons [long interspersed nuclear elements (LINEs, 17.3%), short interspersed nuclear elements (SINEs, 3.3%) and long terminal repeat elements (LTRs, 6.8%)]. Unique heat shock protein gene variants in the indigenous breeds provide insights into their adaptability. This assembled genome resource, developed at ICAR-National Research Centre on Pig, will advance porcine functional genomics and research.

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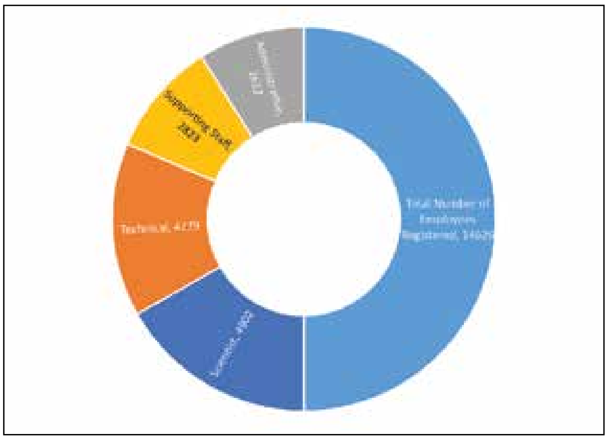
15.

Information and Communication Technology (ICT) and Digital Resources

ICAR's ICT systems are transforming agricultural governance, research, education, and farmer outreach, fostering efficiency and transparency. Platforms like e-HRMS 2.0 streamline HR services for 14,626 employees, integrating functions like leave, reimbursements, and training, while SPARROW simplifies performance appraisals by linking to research achievements via ARMS 2.0. Attendance systems incorporate Aadhaar-based face authentication through AEBAS, and e-Office enhances workflow at ICAR Headquarters and 113 ICAR institutes. The DARPAN Dashboard dynamically updates agricultural project data, while Kisan Sarathi connects 250 lakh farmers to experts via mobile apps and IVR systems. Other initiatives, like the Krishikosh repository with 52 million pages of agricultural knowledge and the Kisan Mobile Advisory Service, disseminate crucial information to farmers. In research and education, ICAR's ORPIMS-NASF supports proposal submissions, and the Technology Certification portal facilitates technology evaluations. The Education Portal manages academic programmes, fellowships, and mobile apps like for Student READY programmes. Over 5,600 issues have been resolved through a centralized e-Support System. To secure digital operations, ICAR has adopted robust cybersecurity measures, including audits, training, and national cyber forum participation. ICT innovations in precision agriculture integrate technologies like remote sensing, IoT, drones, and AI, fostering sustainability and resource efficiency. Sentinel-2 satellite data combined with machine learning generates real-time Leaf Area Index (LAI) maps, while drone-based 5G networks enhance connectivity. Smart irrigation systems, such as IoT-enabled sub-surface drip irrigation, have achieved water savings of up to 95% while improving yields. Precision nitrogen management and AI-driven pest forewarning systems optimize resource use and pest control. Advanced solutions, including AI-based jute grading, mango sorting, robotic apple harvesting, and thermal imaging for livestock mastitis detection, enhance productivity and quality. Aquaculture innovations like IoT-based dissolved oxygen management and UAV-based water quality assessment further contribute to sustainability. ICAR's mobile apps empower agricultural and livestock management. The IkshuKedar app optimizes irrigation scheduling for sugarcane, while GAPs for Indian Non-FCV Tobacco provides guidance on good practices for non-FCV tobacco. CROP SURAKSHA delivers pest management strategies for 15 crops in Andhra Pradesh, and AI-DISC identifies 70 crop diseases and 37 pests using AI. In livestock, AI-DISA detects diseases like Mastitis and Foot and Mouth Disease. Apps like Sabji Gyan offer comprehensive vegetable management guides, while SHRIA, a virtual assistant, supports livestock and poultry health in multiple Indian languages. ICAR also excels in developing databases and tools for agricultural research. The Trait Specific Germplasm system evaluates multilocation accessions, while the Pulse Gene Bank and GARUD provide critical germplasm and genomic data for pulses and rice. The Mustard Family Explorer consolidates information on mustard varieties, and CrustaceaRIS and HilsaTranscripSSRDB offer extensive species and transcriptomic data. Machine learning tools, such as ASPTF, AScirRNA, DBPMod, and RBProkCNN, predict abiotic stress tolerance and DNA/RNA-binding proteins. Databases like MgSatDB for marigold, SesameGWR for sesame, and PredPSP for photosynthetic proteins further advance crop improvement. Collectively, these systems empower researchers, farmers, and policymakers, driving innovation and sustainability in Indian agriculture.

ICT Systems for Operations and Management of ICAR Activities

Electronic Human Resource (HR) Management System (e-HRMS 2.0): The e-HRMS 2.0 is an online platform streamlining HR services for Ministries, Departments, and Organizations (MDOs). It handles leave, deputation, tours, reimbursements, training, profile updates, pay matters, and vigilance clearances with real-time tracking and personalized notifications. Accessible at https://e-hrms.gov.in via NIC email credentials, it provides a transparent, paperless experience. Employees update profiles for nodal officer approval. In 2024, the leave module became fully operational at ICAR Headquarters, with LTC, tour approvals, and reimbursements also active. Additionally, all ICAR Institutes, Regional Centres, KVKs have been onboarded to e-HRMS (14,626 employees), with the leave module operational across all institutes, and



ICAR employees registered on e-HRMS

implementation of other modules currently in progress. During the reporting period, nine training programmes were conducted nationwide to prepare nodal officers for a smooth transition to e-HRMS 2.0. Customization efforts are underway to align the portal with ICAR's needs, including promotion policies, vacancy tracking for ARS cadres, and financial record functionalities. A request for further customization to address specific ICAR cadres, such as technical and scientific staff, has been submitted to the Department of Personnel and Training (DoPT). ICAR Headquarters is actively coordinating with DoPT and the Controller General of Accounts (CGA) to enable payroll activation via PFMS and implement necessary upgrades to meet evolving organizational requirements.

Smart Performance Appraisal Report Recording Window (SPARROW): SPARROW is an innovative online platform developed to enhance the performance appraisal process for government employees by maintaining comprehensive appraisal records for each individual. Within the ICAR, SPARROW has been effectively implemented for all employee categories, i.e. Scientific, Technical, Administrative, and Supporting staff (http://sparrow.icar.gov.in). This platform fetch the data related to research projects, publications, technological developed and capacity building for the scientific cadres of the ICAR from Agricultural Research Management System (ARMS) digital platform through API, facilitating the creation of accurate APARs for scientific personnel. During the year 2023-24, a total of 15,993 Performance Appraisal Reports (PARs) were generated.

Main dashboard of SPARROW showing details for 2023-24

Agricultural Research Management System (ARMS 2.0): The upgraded online portal, ARMS 2.0, developed using ASP.NET and SQL Server, is now available for all ICAR scientists to submit their research achievements. Key enhancements include the ability to add projects with multiple team members, specify extension and abeyance periods, and easily search and add team members from the same or other institutes. Additionally, data from the KRISHI Portal can be imported and saved locally in ARMS 2.0, and scientists can record both national and international awards received. A new Application Programming Interface (API) (http://aparapi.icar.gov.in) has also been created to share major scientific achievements with the SPARROW portal. A dashboard has been designed to visually showcase significant scientific achievements.

ARMS Dashboard

AADHAR Enabled Biometric Attendance System (AEBAS): To align with technological advancements, AADHAAR Face authentication-based AEBAS has been introduced at ICAR headquarters and institutions for attendance marking via mobile devices. This system uses the employee's Aadhaar repository photo for face authentication. The attendance process remains unchanged, with the addition of face biometric-based marking alongside existing fingerprint and iris scans.

ICAR eOffice: The e-Office software developed by the National Informatics Centre (NIC) has been successfully implemented across 113 ICAR institutes, including their regional and sub-stations. During the reporting period, ICAR's e-Office and SPPAROW systems were migrated from the ICAR Data Centre to the NIC Cloud/Data Centre to enhance accessibility, security, and efficiency.

	Electronic Files	Physical Files
Created	6,606	65
Closed	49	3
In-movement	5,584	57
Parked	973	5
Total	6,557	62

Status of e-files and physical files of ICAR

ICAR DARPAN Dashboard (http://icar.dashboard.nic.in): The ICAR Darpan Dashboard, a customized version of DARPAN developed by NIC, is designed to transform complex government data into clear and compelling visuals. It has been deployed on

ICAR Darpan Dashboard displaying its 12 project categories

a common national framework, enhancing analytical capabilities by consolidating data from multiple sources into a single, easily accessible platform. All ICAR schemes and projects are organized into 12 major project categories, encompassing a total of 45 Key Performance Indicators (KPIs). Among these, projects related to Mobile Agro-advisories, Farmer Training, and Extension Activities are dynamic, with district-level data updated via API from the KVK Portal. Additionally, eight new projects comprising 20 new parameters have been added to the ICAR dashboard, with data for these also transmitted via API from the KVK Portal.

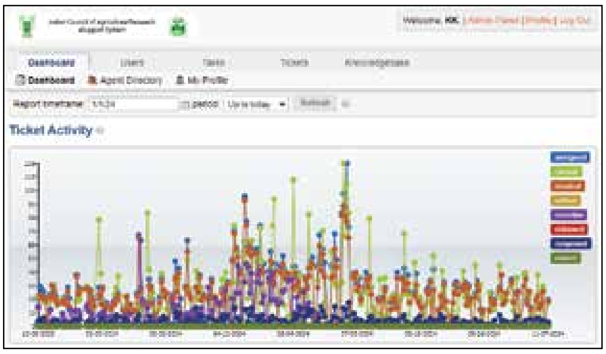
eProcurement System: The Central Public Procurement Portal (CPPP) (https://eprocure.gov.in/eprocure) is an online platform designed to streamline government procurement across India. The ICT Unit at ICAR has been assisting ICAR institutes with onboarding to the CPPP portal, including setting up and updating Nodal Officer details. Over the reporting year, approximately 35 complaints, primarily regarding Nodal Officer updates, were successfully resolved. Currently, all ICAR institutes are registered on the CPPP platform, which enables free online bidding and tender publication.

Foreign Visit Management System (FVMS) of DARE-ICAR: The FVMS of DARE-ICAR is an online system for managing foreign visits, training, and fellowships undertaken by ICAR employees. Employees can submit applications through the portal at https://fvms.icar.gov.in. The workflow has been redesigned according to updated guidelines, offering two options: (i) approval at ICAR or (ii) approval at DARE. These modified workflows have been implemented, and proposals are now processed accordingly.

Cyber Security and Communication Network Management in ICAR: A comprehensive cybersecurity audit was conducted at ICAR Headquarters, covering offices at Krishi Bhawan, Krishi Anusandhan Bhawan-1, Krishi Anusandhan Bhawan-2, and the NASC Complex. Key audit components included creating an inventory of ICT equipment, such as network and endpoint devices, and implementing robust endpoint security solutions. Obsolete network equipment was replaced, and network connectivity for outdated and unsupported endpoints was removed to comply with the GoI's cybersecurity guidelines. Cybersecurity directives from the Ministry of Electronics and Information Technology (MeitY), GoI, were also circulated among staff to raise awareness and promote best practices in the workplace. Essential networking services were provided during significant national and international conferences hosted by ICAR at the NASC Complex. Noteworthy events included the 3rd Annual Chief Secretaries Conference attended by the Hon'ble Prime Minister of India (27–29 December, 2023), the 32nd International Conference of Agricultural Economists (August, 2024), and the ITU/FAO Workshop (March, 2024). Additionally, ICAR participated in the Cyber Swachhta Kendra (CSK) initiative by MeitY, which identifies IP addresses compromised by botnets or malware to secure network services.

Cybersecurity awareness training sessions were organized for scientific, administrative, and technical officers across various research institutes, reaching over 350–400 participants through both online and in-person sessions. ICAR also engaged with key cybersecurity forums, including the Cyber Security Governance and Risk Assessment and Management Workshop by the Computer Emergency Response Team of India, the 'Securing Tomorrow: Unravelling the Intersection of AI and Cyber Security' workshop by NITI Aayog, New Delhi, and the National Conference on 'Challenges Posed by Artificial Intelligence (AI)' organized by the Ministry of Home Affairs, GoI, at the National Forensic Science University in Gandhinagar.

eSupport System for eGov applications in ICAR: A centralized help desk in the form of a web application, available at https://esupport.icar.gov.in, has been implemented to address issues and concerns related to ICAR's web applications and services, including ICAR-ERP, ARMS, Personnel Management System, eHRMS, FVMS, and others. Users can submit their requests or issues for resolution and track progress of their resolution through system-generated ticket number. Also, support personnel at the backend resolve issues and update users about the stage of resolution through this platform. This is a complete ticketing and tracking system for issue resolution. During 1 January 2024 to October 21, 2024, some 5,745; 6,437; and 5,681 tickets were opened, assigned and closed, respectively.



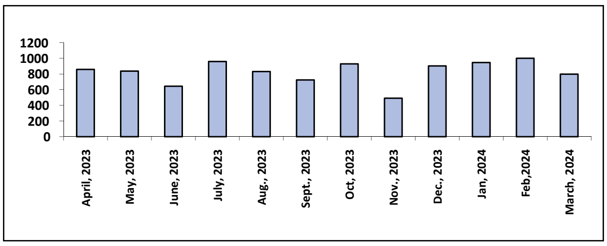
Kisan Sarathi: The online platform 'KisanSarathi' (System of Agri-information Resources Auto-transmission and Technology Hub Interface) was launched by ICAR (https://kisansarathi.in/). It aims to provide seamless, multimedia, multi-way connectivity to farmers, delivering the latest agricultural technologies,

knowledge, and access to a large network of subject matter experts (SMEs). Currently, Kisan Sarathi services are available in all States and Union Territories via an IVR-based calling system, accessible through toll-free numbers 1800-123-2175 and 14426. Additionally, a Kisan Sarathi mobile app for farmer (KS-App/F) is available on the UMANG platform of MeitY, Government of India. Altogether, it supports 13 languages, including 11 major regional languages along with English and Hindi. Nearly all KVKs across India and DATTC centres in Andhra Pradesh and Telangana are enrolled in the system, along with approximately 3,048 SMEs. During the reporting period, over 250 lakh farmers were registered and 18.3 crore advisories were sent to farmers via SMS. Around 1.32 lakh calls were received from the farmers during this period. Development of the second phase, Kisan Sarathi 2.0, is underway, aiming to introduce new features such as Kisan Sarathi: Kosh (Agricultural Advisory Management System), on-boarding of CSCs to offer Kisan Sarathi, Krishi e-Nidanshala services, and integration with Kisan Call Centres (KCC).

Agricultural Query-Response Generation System for Assisting Nationwide Farmers (AgriResponse): A framework for a text-based query-response generation system has been developed to cope with the demand for timely help to the nationwide Indian farmers. Past eight years' call-log records from the countrywide farmers' helpline network are collected and processed to construct the knowledge base that can answer plant-protection-related questions. Three response-retrieval models with approximate matching and spatial-based searching functionality are developed to administer the user input questions and extract relevant answers from the base. To validate the developed framework, a diversified question bank consisting of 755 queries covering 151 crops in India is compiled. Three metrics (Accuracy Percentage, Crop-weighted Performance Score, and Average Response-retrieval time) are considered for the models' assessment. Experimental results show that AgriResponse is a practical framework in real-world applications, with different retrieval models useful for different scenarios. The helpline operators can also use the proposed framework as a second opinion to the experts' advice.

Mobile advisory services: The Kisan Mobile Advisory Service (KMAS) is an ICT initiative providing farmers with customized, real-time agricultural information to enhance decision-making. Delivered via text messages and voice calls, KMAS covers topics like crop production, livestock management, weather forecasts, marketing, and agricultural technologies. KVKs send tailored advisories to registered farmers based on local expertise. In total, 3,49,714 messages were sent to 61.4 lakh farmers, with the majority focused on crops (1,30,747), followed by weather (87,943), livestock (60,635), awareness (22,747), other advisory services (34,433), and marketing (13,209).

E-Granth: Krishikosh (https://krishikosh.egranth.ac.in/) is a digital repository that captures, preserves, and provides policy-based access to the intellectual output of India's National Agricultural Research and Education System (NARES). It hosts a diverse collection of theses, rare books, institutional publications, technical bulletins, project reports, and other valuable documents from ICAR institutes and SAUs, aligning with ICAR's open-access policy. With over 520 lakh digitized pages, including 1.9 lakh theses, it is a key resource for agriculture and allied sciences. A tool has also been developed to analyse research trends by examining keyword frequencies in theses titles on Krishikosh. This tool highlights focus areas in Indian agricultural research and tracks trends reflecting national priorities. Metadata analysis quantifies attention on specific topics and technologies, while monthly upload data offers insights into research productivity and interest peaks. The Krishikosh repository has been upgraded to DSpace version 7.2, introducing advanced features such as runtime configuration for the user interface, item embargo/restriction settings in the submission interface, OpenID Connect (OIDC) authentication, a "filter-media" option in the process interface, enhanced support for custom "Browse By" configurations, and compatibility with JDK 17. From 1 April, 2018, to 31 March, 2024, Krishikosh recorded 285 lakh hits, with visitors from 175 countries. The top five countries include India, the United States, China, Ethiopia, and Russia. This platform now serves as a unified repository for sharing intellectual outputs from NARES, ensuring 24/7 online access to an extensive knowledge base.



Theses (no.) uploaded in Krishikosh (April 2023-March 2024)

ORPIMS-NASF: An Online portal for Research Pre-proposal Management and Information System for National Agricultural Science Fund (ORPIMS-NASF) has been successfully designed, developed and tested by ICAR-IASRI, New Delhi. The system is being used to take research pre-proposal for NASF call (https://nasf.icar.gov.in/). After completion of the call, reports are generated for the smooth completion of the initial evaluation of the submitted project.

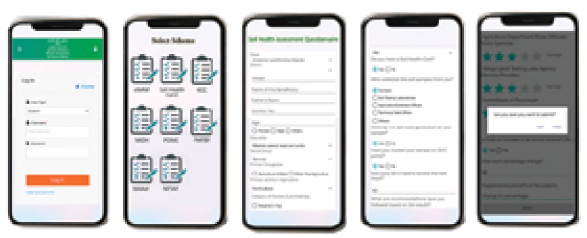
Technology certification application: ICAR-IASRI developed a Spring Boot-based workflow application with CAS authentication for certifying technologies, products, processes, concepts, methodologies, models, protocols, and policies developed by ICAR. The application, available at https://krishi.icar.gov.in/technologyproduct/, allows all technology certification proposals to be submitted. Information should be uploaded after ITMC approval and will undergo a stepwise approval process from SMD.

Education Portal: Developed under the National Information System on Agricultural Education Network project, the education portal (https://education.icar.gov.in) manages ICAR's Education Division activities. It serves as a centralized hub for information and resources related to agricultural education and research in India. The portal complies with GIGW guidelines and underwent a security audit. New modules added to enhance its functionality are as follows:

Netaji Subhas-ICAR International Fellowship: The fellowship application form was redesigned with role-based authentication and a dashboard for tracking applications. A mailing system was integrated for email notifications. (https://education.icar.gov.in/NetajiSubhasNotification)

Student READY (Rural Entrepreneurship Awareness Development Yojana): A new module allows students to apply for various programs (RAWE/IPT/Internship/Experiential Learning). Students can submit weekly reports and summaries, while nodal officers approve applications and generate reports. (https://education.icar.gov.in/Student_Ready)

VIKAS-Venture for Interaction of Kisan and Agri-Students: A mobile app developed for students to collect feedback from farmers on government schemes. The app integrates with the RAWE framework and allows students to report on activities related to soil health cards, FPOs, natural farming, and extension services. API integration enables seamless data exchange with the Education Portal.



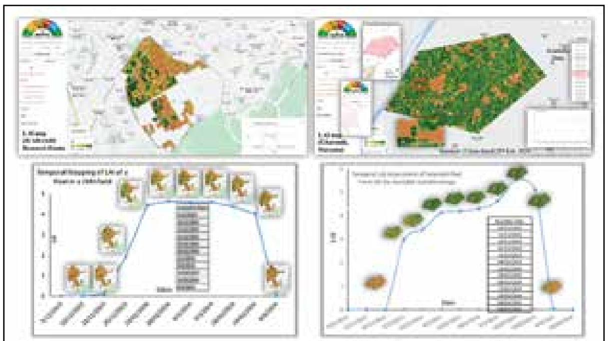
VIKAS App depicting screenshots of different forms and login

ICAR OPAC Union Catalog: IDEAL is a Software as a Service (SaaS) platform tailored for NARES libraries, offering an Integrated Library Management System (ILMS) for streamlined digital library operations. It includes AgriCat, a union catalog that facilitates shared holdings across libraries, minimizes duplicative purchases, and provides an Online Public Access Catalog (OPAC) for remote access to resources. Hosted on secure servers at the ICAR-IARI with mirror backups, the platform ensures high availability and real-time updates. Its key features include (i) unified and individual searches across all ICAR libraries with advanced filtering options; (ii) real-time book status and location (available/issued/lost); (iii) reduced duplication of book acquisitions; (iv) inter-library loan services for authorized users; (v) access to real-time data for better decision-making and (vi) detailed reporting to enhance management and educational quality in agricultural institutions.

ICT Systems for Precision Agriculture

The 'ICAR-Network Programme on Precision Agriculture (NePPA)' leverages cutting-edge technologies like remote sensing, IoT, drones, variable rate technologies (VRTs), and big data analytics for sustainable production and efficient resource use. Key achievements are outlined below:

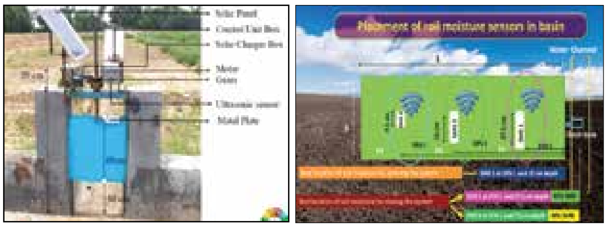
Near real time monitoring from a single field to large scale using remote sensing: Models for near real-time crop monitoring utilize Sentinel-2 data, offering high-resolution insights into LAI (Leaf Area Index) at various scales. Using Google Earth Engine and a Gaussian Process Regression (GPR) model trained on PROSAIL simulations, researchers validated the approach with *in situ* data from IARI farms in New Delhi, producing an LAI map for large croplands in Haryana.



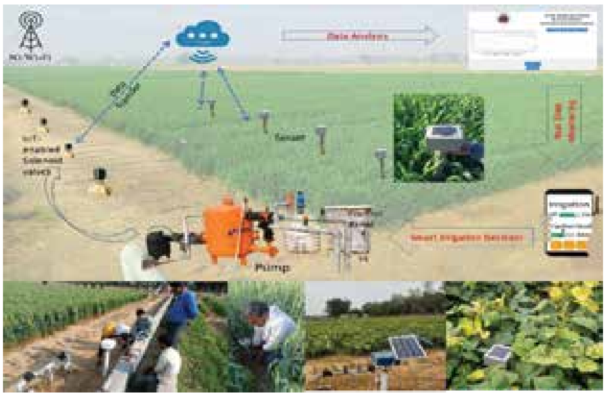
Drone-based 5G captive network on demand for smart farming: The Network-in-a-Box (NIB) is a self-contained solution designed for the swift deployment of private 5G networks in a limited manner. It combines a fully-functional 5G SA Core and 5G RAN into a compact and portable unit, enabling users to establish a complete 5G network with minimal configuration. The pre-integrated design and intuitive user interface of

NIB expedite network setup, minimizing downtime and simplifying the deployment process. NIB's versatility allows for adaptation to diverse deployment scenarios and spectrum requirements. The NIB's controlled environment makes it perfect for testing and simulating 5G network behavior in a variety of conditions.

Soil-moisture sensor-based automatic basin irrigation system: A sensor-based automatic irrigation system consisting of sensing unit, communication unit, and control unit was developed and evaluated in the IARI research farm with wheat crop. Low cost capacitance based soil moisture sensor, microcontroller, check gate with control unit were integrated together and powered from solar panel. Communication among them was established using LoRa and GSM. A total of 25% of water was saved through real-time soil moisture status-based automatic irrigation systems than the conventional manually controlled system under wheat crop.



IoT based sub-surface drip irrigation automation in cereal-based cropping system: Automatic sub-surface drip irrigation system having dripper installed at 20 cm depth, fertigation system, electric water pump, soil moisture sensor (SMS), solenoid valve enabled with solar panel and cloud server with a simple smartphone interface for soil moisture monitoring and irrigation scheduling was done in the IARI field. Due to the sub-surface drip system water application efficiency achieved > 95% water saving, 30-40% nutrient saving, crop yield increased by 25% and B:C ratio 1.85-2.1.



Sensor-based irrigation automation for alternate wetting and drying (AWD) in transplanted rice: A sensor-based irrigation automation system for alternate wetting and drying (AWD) in transplanted rice was developed using ultrasonic sensors to monitor water levels. Field tests in 2023 showed similar grain yields (4.21 tonnes/ha) with 18% less water use (1,100 mm)

and a 15% increase in water productivity (0.38 kg/m³).

Developing precision nitrogen management protocols for rice using remote sensing and geospatial tools: Nitrogen recommendations for farmers' fields were upscaled using multispectral satellite and drone-mounted sensors to enhance nitrogen-use efficiency. A Random Forest-based predictive model was developed and validated, identifying key influential variables. The model's outputs were applied to generate nitrogen level maps, demonstrating its practical utility.

AI integrated IoT for pest forewarning system: ICAR-CICR, Nagpur, developed an AI-based smart pheromone trap for real-time monitoring of pink bollworm in cotton. Using a YOLO-based machine learning algorithm with 91.4% detection accuracy, the trap captures insect images, counts them, and transmits data along with weather parameters hourly to a remote server.

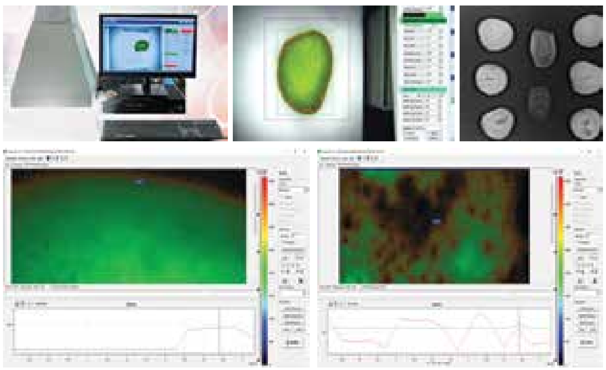
The system has been successfully deployed in Punjab.

Development of precision soil fertilizer recommendation system: An e-Precision Fertilizer Recommendation System has been developed integrating soil analysis, digital mapping, and target yield data to provide personalized fertilizer advice for farmers. Supported by a mobile and web-based platform, it uses geospatial tools and digital soil maps to help optimize crop yields and farming practices.

AI and IoT enabled jute grading system: An AI and IoT-enabled jute fiber grading system has been developed for rapid and precise measurement of five key quality attributes of jute and mesta fibers. The system includes a feeding tray, sample conveyor, image capturing unit, color measurement module, and

bundle strength measurement units. It employs a hybrid machine learning-based image processing and sensor-based approach. The device is user-friendly, delivering results within 5 min with over 90% accuracy compared to traditional grading methods. This innovation reduces time and labour while ensuring better remuneration for jute fibers, enabling stakeholders to determine fiber grades efficiently in the field.

Machine vision system for mango sorting and grading: A machine vision system was developed for inspecting mango features, providing real-time data via a GUI and PLC for tasks like sorting blemished fruit and optimizing production process. It enhances consistency in sizing and sorting while enabling automated defect detection. Preliminary trials using fluorescence imaging showed promise for predicting ripeness and detecting internal defects like spongy tissue in Alphonso mangoes.



AI-based detection module for a robotic apple harvester: An AI-powered detection module for a robotic apple harvester was developed to enhance accuracy in detecting and localizing apples in dense orchards. Built using a PyTorch-based model, it was tested under real field conditions. Enhancements like GhostNet and BiFPN were added to optimize feature extraction. The model achieved 96% accuracy in detecting apples under various lighting, with 90% accuracy for hidden fruits. A modified depth calculation further improved detection accuracy to 92% at 0.3 m and 96% at 0.4–0.9 m. This module streamlines the harvesting process, boosting efficiency and yield.

AI-based mastitis disease identification in cattle and buffalo: Mastitis symptoms in cows, particularly in the mammary glands (teat area), were analyzed using thermal images of the Sahiwal breed provided by ICAR-NDRI, Karnal. The images were categorized into three groups: Normal (healthy), Clinical (infected), and Sub-clinical (early infection stage). A Deep Learning-based Convolutional Neural Network model was trained under two conditions: Normal vs. Clinical and Normal vs. Sub-clinical. Additionally, a web-based tool was developed, allowing users to upload thermal images of udders for mastitis detection in animals.

AI-based detection of insects, pests and diseases: A total of 1,307 RGB images of Red Rot, Wilt, Smut, PokkahBoeng, YLD, Top Rot, Leaf Scald, Leaf Scorching, Ratoon Stunting Disease, Scale Insect, Mealy bug, White fly, Aphid, Black bug, Top Borer, Internode borer, Termite and Porcupine damage symptoms were captured manually through different cameras (Canon EOS 77D DSLR camera, smartphone One Plus 7T Pro HD1911 (OnePlus Technology (Shenzhen) Co., Ltd.) Android Version 11 (Oxygen OS 11.0.7.1 HD01AA), SnapdragonTM 855 plus processor) camera and 16.1 MP Sony Cyber-Shot DSC-H70 with 10× Wide-Angle Optical Zoom G Lens camera). The images were collected from susceptible varieties such as Co 0238, CoJ 85, CoJ 64, CoSe 18452, CoLk 94184, CoLk 14201, CoS 8436, Co 1148, CoLk 11203 and CoS 767 etc. In total, the image repositories of 15, 746 RGB images of insects, healthy and injured symptoms of insects, pests and diseases are available at SPID dataset.

Drone-based water sampling and quality assessment for inland open water bodies: ICAR-CIFRI, Barrackpore, developed a UAV-based vertical water sampling system for collecting water samples from large or inaccessible water bodies, difficult terrains, highly polluted sites, etc. The water sampler can collect one litre of water in single attempt. This approach enables assessment of water quality and emerging contaminants, supporting aquatic health monitoring and raising awareness about contaminants' impact on

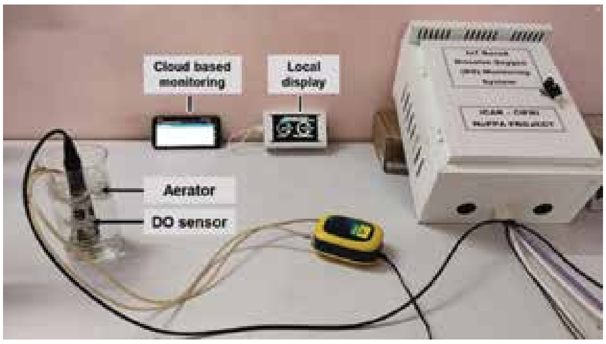
biodiversity and public health.

IoT based dissolved oxygen monitoring and management system: ICAR-CIFRI, Barrackpore, developed an IoT based dissolved oxygen (DO) management system which continuously measures the DO levels in water body as well as operate the aerator automatically in case of low DO level to manage the stress condition. The system was tested in different water bodies and validated the DO reading with other commercially available DO sensor and laboratory tested results.The device is connected to the cloud via Internet. It senses the DO level and temperature at intervals and uploads the data in cloud in real-time. The continuous DO and temperature data can be accessed through devices via internet.

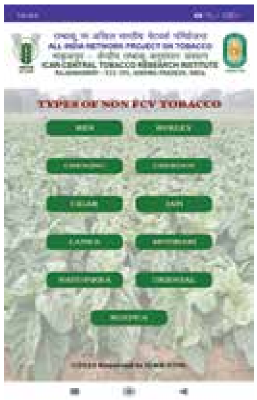
Smart fish feeder for pond, RAS, and aquarium: Smart Feeder is a viable solution to address feed optimization in pond-based commercial aquaculture, RAS, BioFloc, koi ponds, aquariums and ornamental fish rearing tanks. By automating feed dispensation, this innovative device helps reduce costs, improve feed efficiency, and enhance sustainability. There is an integrated IP camera that monitors fish and feeding activity and gives informed decisions and timely issue resolution. It also allows IoT Integration and Remote Monitoring to manage feeding activities remotely. It is monitored and controlled via iCAR-CIFA AquaMegh App (Android and iOS).

Mobile Apps for Smart Farming

IkshuKedar mobile app for precise irrigation scheduling for sugarcane cultivation: ICAR-Indian IISR, Lucknow, has developed a mobile app, 'IkshuKedar' (Reg. No: SW-16350/2023), for intelligent irrigation scheduling in sugarcane production under North Indian conditions. The app enhances water-use efficiency and productivity by recommending the optimal timing for irrigation, reducing the water footprint without affecting crop performance. Users can query the next irrigation date, confirm a given date, and receive advisories on irrigation scheduling and app usage. Designed in Hindi for Android devices, the app functions offline once downloaded. (https://play.google.com/store/apps/details?id=in.gov.icar.iisr.irrigationmanagementinsugarcane)



GAPs for Indian Non-FCV Tobacco mobile app: A mobile application on Good Agricultural Practices (GAPs) for Indian Non-FCV Tobacco has been developed using Android Studio with Java and XML programming. The app offers comprehensive information on non-FCV tobacco types, recommended practices, and available research infrastructure across various locations. Featuring an intuitive, icon-based interface, the app ensures easy navigation and quick access to its features with a single click. It is available for download at https://play.google.com/store/apps/details?id=com.nonfcv.myapplication.



CROP SURAKSHA mobile app: An Android-based mobile app, 'CROP SURAKSHA', has been developed and hosted on the Google Play Store to deliver Integrated Pest Management (IPM) technologies directly to farmers. The app provides IPM practices for 15 major crops,

including cereals, pulses, oilseeds, and commercial crops predominantly grown in Andhra Pradesh. It features detailed information on managing various pests and diseases, supported by illustrations, images, photos, and trade names, all presented in the Telugu language for easy comprehension by the farming community. The URL is https://play.google.com/store/apps/details?id=com.companyname.cropsuraksha&hl=en_IN

AI-DISC: The Artificial Intelligent based Disease Identification System for Crops developed by ICAR-IASRI, New Delhi, was further strengthened by adding models for identification of new diseases and pests in crops (7 diseases in 3 crops and 37 insect pests in 8 crops). Presently AI-DISC is enabled for identification of 70 diseases of 22 crops and 37 insects for 8 crops using image data.

AI-DISA: The Artificial Intelligent based Disease Identification for Livestock mobile application developed by ICAR-IASRI, New Delhi and ICAR-IVRI, Bareilly, is capable of identifying visible diseases in livestock. Presently AI-DISA can identify Foot and Mouth Disease, Mastitis and Lumpy Skin Disease in Bovine, Canine Distemper, Canine Parvo Virus, Rickets, Mange and Mamary Tumor in Canine.

Sabji Gyan Mobile Application: The ICAR-IASRI in collaboration with ICAR-IIVR, Varanasi, has designed and developed 'Sabji Gyan' mobile app. The app is available in Google play store (https://play.google.com/store/apps/details?id=net.iasri.iivr.sabji.gyan&hl=en&gl=US) in Hindi and English languages. This application serves as a comprehensive guide, offering detailed insights into the cultivation and effective management of a wide array of vegetable crops. Users can access a wealth of information, including step-by-step guidance on optimal planting practices, soil preparation, irrigation methods, pest control strategies, and harvesting techniques.

Smart Hueristic Response based Intelligent Assistant (SHRIA): A conversational virtual agent 'Chatbots' named SHRIA (Smart Heuristic Response based Intelligent Assistant) using advanced Natural Language Processing (NLP) algorithms was developed by ICAR-IASRI in association with ICAR-IVRI, Izatnagar. The purpose is to carry out a real-time conversation with its users for improving livestock, pet, poultry health and production. The application can understand and communicate in different Indian languages, ensuring accessibility and inclusivity for a diverse range of users. It has 'Dairy SHRIA' (https://play.google.com/store/apps/details?id=com.ivriapp.ivri_chatbot.ivri_chatbot) to address various health and production management concerns regarding cattle and buffalo and 'Sheep and Goat SHRIA' for sheep and goats (https://shria-sg.icar.gov.in).

Databases and Online Information Systems for Agricultural Knowledge Management

Trait Specific Germplasm Identified through Multi-Location Evaluation (Decision Support System): A new application, 'Trait Specific Germplasm Identified Through Multi-Location Evaluation (Decision Support System)' was developed by ICAR-NBPGR, New Delhi, for the promising accessions identified under the multilocation evaluation programme.

Pulse Gene Bank: A Germplasm Resources Information System for Pulses with different characteristics of germplasm data were developed for major pulse crops maintained/stored in ICAR-IIPR Gene Bank (https://seedhubiipr.wp.urdemo.website/admin/login.php). The system features a user-friendly interface for entering, modifying, and updating germplasm data based on location and characteristics. Currently, 5,030 accessions are included: Chickpea (1,633), Pigeonpea (793), Lentil (1,721), Fieldpea (678), Cowpea (106), Rajmash (63), and Horsegram (49). Built using WAMP (Windows, Apache, Mysql and PHP) technology, the system offers query-based reports (location, character, and detailed reports) in PDF format. It provides valuable information to researchers, exporters, and policymakers, facilitating the sharing of pulses germplasm data on a digital platform.

Mustard Family Explorer Database: This pioneering platform (https://mustardfamilyexplorer.icar-web.com/) consolidates a wide array of information on Indian mustard varieties. This comprehensive resource encompasses fundamental details such as variety name, oil content, year of release, yield, recommended state, and salient features. Additionally, it offers invaluable genomic data for varieties where molecular and genomic studies have been conducted. It provides a holistic resource for stakeholders in the mustard farming community. This platform serves as a model for similar initiatives in other crop domains, emphasizing the power of integrated databases in modern agriculture. This has been developed by ICAR-IASRI in collaboration with ICAR-NIPB, New Delhi.

Fish Catch Assessment Survey Software: The ICAR-CIFRI, Barrackpore, developed the Fish Catch Assessment Survey Software (CAS ver. 2.0) in collaboration with the Department of Fisheries, Chhattisgarh. This software was customized to estimate fish catch of species such as IMC, pangas, tilapia, and prawn in waterbodies with a water spread area of less than 10 ha.

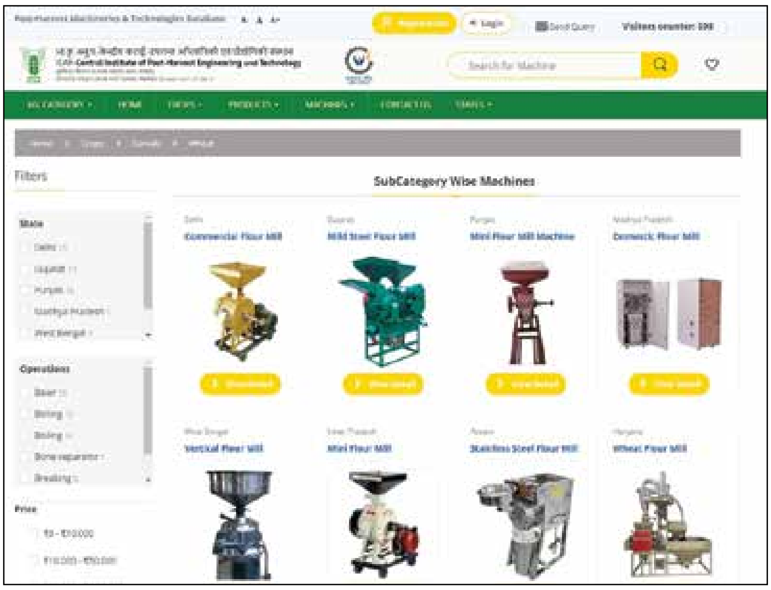
Post-Harvest Machineries and Technologies Database: New and existing business require assistance and technical support for selection of machinery for the processing units. A platform that caters to the specific need of food processing entrepreneurs was needed since long time. The comprehensive database for processing machines, technologies, processes and products that has been developed by NARES institutions and private organisations/industries. The database is primarily divided into 'Processing Machine Technologies' and 'Products/Process Technologies' for different categories of agricultural produce. Databases showcases both type of technologies grouped as per the 12 broad crop categories that are further divided into more than 80 specific crops.

AScirRNA: A machine learning based online prediction tool for the discovery of abiotic stress specific Circular RNAs (circRNAs) in plants, freely available at https://iasri-sg.icar.gov.in/ascirna/.

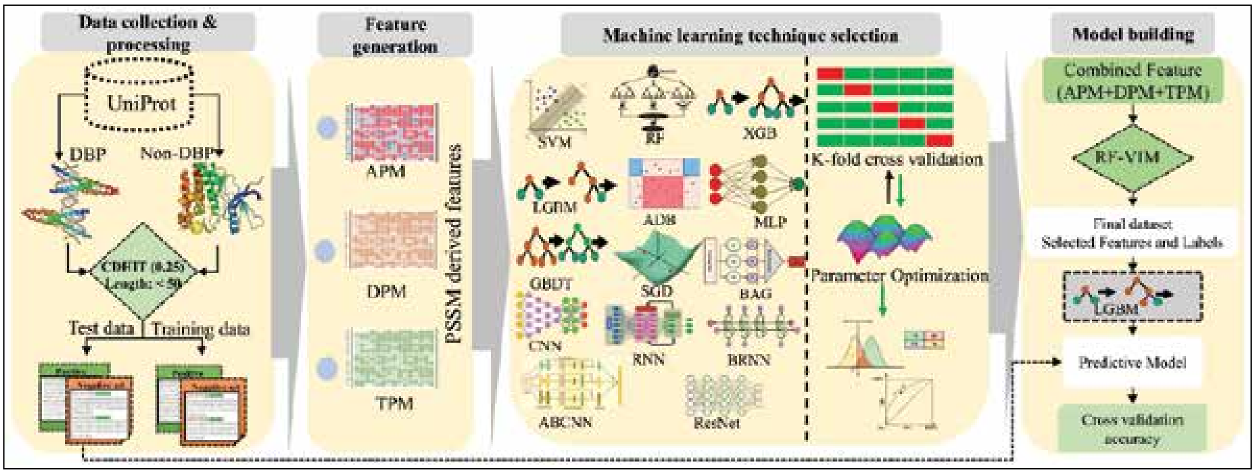
ASPTF: Abiotic stresses pose serious threat to the growth and yield of crop plants. Several studies suggest that in plants, transcription factors (TFs) are important regulators of gene expression, especially when it comes to coping with abiotic stresses. Therefore, it is crucial to identify TFs associated with abiotic stress response for breeding of abiotic stress tolerant crop cultivars. Based on a machine learning framework, a computational model was envisaged to predict transcription factors (TFs) associated with abiotic stress response in plants. The developed web server ASPTF is accessible at https://iasri-sg.icar.gov.in/asptf/.

CCncRNAdb: A web-resource, which serves as a repository for non-coding RNAs (ncRNAs) in common carp that are unique to various tissues, such as barb, blood, bone, brain, bulbus, embryo, eye, fin, gallbladder, gill, gonads, gut, heart, hepatopancreas, hypothalamus, intestine, kidney, larvae, liver, muscle, ovary, pituitary, scale, skin, spleen, tail, testis, and thymus. Users could easily access, explore and retrieve all the information related to lncRNAs and circRNAs from this user-friendly database. The database is available at http://backlin.cabgrid.res.in/ccncrnadb/.

DBPMod: A machine learning based approach to identify species-specific DNA binding proteins (DBPs). Five model organisms, including *C. elegans*, *D. melanogaster*, *E. coli*, *H. sapiens*, and *M. musculus*, were used to assess the performance of DBPMod. The comparative results demonstrated that the DBPMod outperforms 12 state-of-the-art computational approaches in identifying the DBPs for all five model organisms. The web server DBPMod is available at https://iasri-sg.icar.gov.in/dbpmod/.



Genetically Aggregated Rice User-Interface Database (GARUD): It is a comprehensive online repository dedicated to Indian rice varieties, providing essential information on released rice (1,200+ varieties) types along with extensive genomic data. It serves as a valuable resource for researchers, farmers, and policymakers to explore the genetic diversity and characteristics of Indian rice. With data supporting crop improvement and innovation, GARUD aids in enhancing



agricultural practices and food security. The repository is managed by ICAR-National Institute for Plant Biotechnology, New Delhi. GARUD is accessible at https://rice-garud.icar-web.com/.

MethSemble-6mA: A machine learning based prediction tool for predicting sequences with 6mA sites. The tool utilizes five different feature sets for DNA sequence vectorization. Nine machine learning models were employed with relevant features selected through the feature selection module. The top three best-performing models, viz. gradient boosting, random forest and SVM, were then combined into a robust ensemble model for prediction. The tool is accessible at http://cabgrid.res.in:5799/.

MgSatDB: A marigold microsatellite marker database. The various customized search options provided in this database will be helpful for future marigold breeding and improvement programmes. Available at http://backlin.cabgrid.res.in/mgsatdb/.

PhytoMicroBioPred: A machine-learning based tool for prediction of compound bioactivity against plant and microbes target proteins. This tool is available at http://login1.cabgrid.res.in:5260/.

PredPSP: An online prediction server based on machine learning for identifying pathway-specific photosynthetic proteins in plants, available at https://iasri-sg.icar.gov.in/predpsp/.

ProkDBP: A novel machine learning-driven computational model for prediction of prokaryotic DNA binding proteins (DBPs). ProkDBP (https://iasri-sg.icar.gov.in/prokdbp/) is available as an online prediction tool, enabling free access to interested users.

RBProkCNN: A deep learning based computational tool for RNA binding protein discovery in prokaryotes. Noteworthy is its superior predictive accuracy when compared to several state-of-the-art existing models. RBProkCNN is available as an online prediction tool (https://iasri-sg.icar.gov.in/rbprokcnn/), offering free access to interested users.

SesameGWR: A web genomic resource for transcriptomic signatures of abiotic and biotic stress responses in sesame (*Sesamum indicum*). This platform provides key insights into differentially expressed genes, transcription factors, miRNAs, and molecular markers like simple sequence repeats, single nucleotide polymorphisms, and insertions and deletions associated with both biotic and abiotic stresses. SesameGWR is available at http://backlin.cabgrid.res.in/sesameGWR/.

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16. Technology Assessment, Demonstration and Capacity Development

The Agricultural Extension Division of ICAR plays a pivotal role in advancing agricultural innovation through technology assessment, demonstration, and capacity development. This is achieved through 11 ATARIs and 731 KVKs. While ATARIs oversee technology application, KVKs conduct on-farm testing (OFTs) and frontline demonstrations (FLDs) to evaluate and promote location-specific technologies; besides conducting training programmes and extension activities for capacity development and large scale diffusion. During the reporting period, KVKs assessed 6,028 technological options of crops, including evaluating 1,758 varieties across 6,895 trials. Livestock assessments focused on nutrition, disease, and feed management, with 5,719 trials conducted at 2,636 locations. Additionally, 624 technologies in farm and non-farm enterprises were assessed, covering mechanization, processing, and small-scale income generation. Cluster Frontline Demonstrations (CFLDs) targeted pulse and oilseed crops, covering 20,206.84 ha for pulses and 26,220 ha for oilseeds. These demonstrated 34.36% yield increase for pulses and 29.40% for oilseeds. Other FLDs in cereals, millets, pulses, and horticultural crops resulted in impressive yield gains, including 45.63% increase in greengram and 40.64% rise in linseed. KVKs also conducted 9,089 farm mechanization demonstrations, alongside 17,830 in livestock and fisheries, and 17,761 enterprise demonstrations, with a focus on women's empowerment. Capacity development was a key priority, with over 20 lakh individuals attending 65,235 training programmes. Of these, 49,534 courses targeted farmers and farm women, with 36.17% from SC/ST groups. Key training areas included crop management, horticulture, livestock, and women's empowerment. Rural youth participated in 10,651 skill development courses, focusing on mushroom production, dairying, and organic farming. KVKs conducted 9.33 lakh extension activities, reaching 395 lakh participants. These activities included diagnostic visits, field days, kisan melas, and media outreach, along with seed distribution. Special programmes like the ARYA project trained 16,952 rural youth, leading to 3,398 entrepreneurial units. The NICRA project, promoting climate-resilient agriculture, reached 49,278 farmers through 9,458 demonstrations. The Nutrition Sensitive Agricultural Resources and Innovation (NARI) programme addressed malnutrition by setting up 13,614 nutri-gardens, benefiting 15,774 families. Bio-fortified crop varieties were demonstrated over 599.88 ha, reaching 2,328 families. This initiative also included 2,285 training programmes and 2,770 extension activities, educating over 160,000 participants. The Crop Residue Management (CRM) initiative addressed the environmental impact of residue burning, engaging 56,000 farmers in awareness camps and 1,100 demonstrations. KVKs also engaged 10,000 farmers through field days. Additionally, 4,416 Integrated Farming System (IFS) demonstrations benefited 59,176 farmers. The Cereal Systems Initiative for South Asia (CSISA) promoted resource-conserving practices and improved productivity. ICAR also promoted FPO formation, training 3,093 FPOs in sustainable practices, and launched the Agri-drone Project, procuring 299 drones for 15,000 demonstrations across 31 states. These efforts collectively enhanced the productivity, sustainability, and resilience of farmers across India.

The Agricultural Extension Division of ICAR focuses on technology assessment, demonstration and capacity development through 11 Agricultural Technology Application Research Institutes (ATARIs) and 731 Krishi Vigyan Kendras (KVKs). ATARIs coordinate and monitor technology application and frontline extension education programmes with headquarters at Ludhiana, Jodhpur, Kanpur, Patna, Kolkata, Guwahati, Barapani, Pune, Jabalpur, Hyderabad and Bengaluru.

The KVKs are district level multidisciplinary scientific institutions mandated for technology assessment and demonstration for its application and capacity development across diverse farming situations. They conduct on-farm testing (OFTs) to identify location specificity of new technologies in various farming systems; frontline demonstrations (FLDs) to showcase their production potential and capacity development programmes for stakeholders. KVKs also provide technological inputs, information and knowledge to different stakeholders and serve as district level knowledge and resource centres. Besides, important programmes taken up are Out scaling of Natural Farming, Formation and Promotion of Farmer

Producer Organizations (FPOs) as Cluster Based Business Organizations (CBBOs), Technological backstopping to FPOs, Demonstrations through Agri-drones, Farmers FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of pulses and oilseeds, Cereal Systems Initiatives for South Asia (CSISA), National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed hubs, Mera Gaon Mera Gaurav and Awareness creation on government schemes, etc.

Technology Assessment

Crops: The KVKs assessed 6,028 technological options at 15,406 farmers field locations through 28,661 trials across all agricultural and horticultural crops. Key themes included varietal evaluation, integrated nutrient and pest management, crop management, weed control, resource conservation, post-harvest technology, and soil health. Other areas assessed included cropping systems, seed/plant production, small-scale enterprises, water management, and biological control. Varietal evaluation was the main focus, with 487 KVKs evaluating 1,758 varieties in 6,895 trials across 3,272 locations. Integrated nutrient management (959 technologies, 4,533 trials at 2,177 locations) and integrated pest management (786 technologies, 4,013 trials at 2,003 locations) were also major areas of focus.

Livestock: The KVKs assessed technologies of livestock production and management across 2,636 locations through 5,719 trials. Key areas included nutrition management, animal disease management, livestock production, feed and fodder management, breed evaluation, fish production, and small-scale income generation. Major themes were nutrition management (239 technologies, 1,675 trials at 659 locations), disease management (170 technologies, 913 trials at 308 locations), and livestock production (158 technologies, 840 trials at 451 locations). The assessments covered a wide range of livestock, including cows, buffalo, sheep, goats, poultry, pigs, and fish, focusing on the suitability of technological interventions.

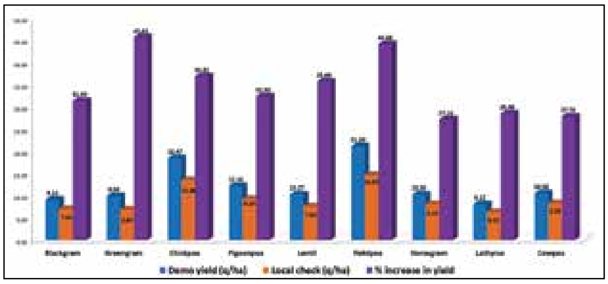
Farm and non-farm enterprises: A total of 624 technologies of farm and non-farm enterprises were assessed at 3,867 locations through 5,347 trials. Key areas included processing and value-addition, mechanization, health and nutrition, small-scale income generation, entrepreneurship, storage, resource conservation, drudgery reduction, post-harvest management, food security, organic farming, and beekeeping. Dominant themes were processing and value-addition (119 technologies, 651 trials at 57 locations), mechanization (99 technologies, 491 trials at 221 locations), and health and nutrition (61 technologies, 349 trials at 90 locations).

Women empowerment: In all, 275 farm women friendly technologies were assessed through 1,855 trials at 900 locations. Health and nutrition (111 technologies, 825 trials at 484 locations); and value addition (96 technologies assessed through 492 trials at 278 locations) were the major thematic areas.

Frontline Demonstrations

Cluster Frontline Demonstrations (CFLDs)

The Agriculture Extension Division, ICAR, New Delhi implemented Cluster Frontline Demonstrations (CFLDs) in collaboration with National Food Security Mission (NFSM) of the Department of Agriculture and Farmers' Welfare, GoI. The programme aimed to demonstrate the production potential of major pulse (chickpea, pigeon pea, lentil, blackgram, greengram) and oilseed (sesame, groundnut, linseed, soybean, mustard, sunflower) crops in key states like Andhra Pradesh, Bihar, Gujarat, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Madhya Pradesh, Uttar Pradesh, and West Bengal. Key components included analysing district-



Yield performance of pulse crops

CFLD on Lentil (Var L-4717) – KVK Nadia, West Bengal (Zone-V Kolkota)

CFLD on Blackgram (Urd PU-7)-KVK-II Muzaffarnagar (Zone-III Uttar Pradesh)

CFLD on Greengram (Var Pramed L.)-KVK Rohtas (Zone-IV Patna)

CFLD on Blackgram (PU-31): KVK Imphal East (Zone VII Barapani)

CFLD on Field pea : KVK Sepahijala, Tripura (Zone VII Barapani)

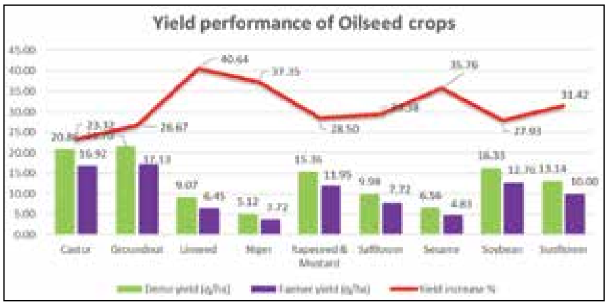
CFLD on Chickpea (CSJ-515): KVK Tonk, Rajasthan (Zone-II Jodhpur)

CFLD on Redgram (Var. PRG-1): KVK Nalgonda (Zone-IX, Hyderabad)

CFLD on Rajmash (Shalimar rajmash): KVK Bandipora (Zone-I Ludhiana)

specific constraints, preparing technology modules, and upgrading the knowledge and skills of KVK staff and extension workers.

CFD on Pulses: During the period under report, 20,206.84 ha area were covered under 49,996 demonstrations on pulse crops across the country. In *kharif* season, 12,140.45 ha area (28,201 demonstrations) were covered, followed by 7,391.39 ha (20,204 demonstrations) in *rabi*, and 675 ha (1,591 demonstrations) in summer. The national average yield advantage for major pulse crops was 34.36%, with the highest gains in greengram (45.63%), followed by field pea (44.08%), chickpea (36.82%), lentil (35.66%), pigeon pea (32.30%), blackgram (31.34%), lathyrus (28.48%), cowpea (27.78%), and horsegram (27.16%). These improvements were driven by increased farmer awareness and skill development through KVK interventions.



Yield performance of oilseed crops (q/ha) under CFLD on oilseeds (2023-24)

Demonstration on Sunflower (RSC-1046), KVK Kawardha (Chhattisgarh)

Demonstration on Castor (ICH-5), KVK Kurnool (Andhra Pradesh)

Demonstration on Sesame (ST-1683), KVK Baksa (Assam)

Demonstration on Mustard (RH-725), KVK Jehanabad (Bihar)

CFLD on Oilseeds: During the reporting period, CFLDs on oilseed crops were conducted in 26,220 ha through 67,850 demonstrations. In *kharif,* 8,730 ha (22,511 demonstrations) were covered, while 15,400 ha (39,838 demonstrations) and 2,090 ha (5,501 demonstrations) were covered in *rabi* and summer, respectively. The national average yield advantage for major oilseed crops was 29.40%, with the highest gains in linseed (40.64%), followed by niger (37.35%), sesame (35.76%), sunflower (31.42%), safflower (29.38%), mustard (28.50%), soybean (27.93%), groundnut (26.67%), and castor (23.32%). These results were driven by appropriate technological interventions, farmer skill development, and awareness through KVKs.

Other Frontline Demonstrations (FLDs)

A total of 1,47,985 FLDs, other than CFLDs, including 91,127 FLDs on crops covering 28,811.98 ha, 9,089 demonstrations on farm machinery covering 4,880.34 ha, 19,919 FLDs on livestock and fisheries, 17,761 demonstrations on other enterprises and 10,089 FLDs on gender-specific technologies for women empowerment were organized.

Cereals: A total of 13,113 FLDs on 1,528 paddy varieties and management technologies were conducted across 4,569.91 ha by 382 KVKs, with an average yield increase of 17.84% over farmers' practices. On wheat, 1,196 varietal and technology options were demonstrated in 9,539 FLDs covering 6,369.33 ha, resulting in a 14.48% yield increase. For maize, 108 KVKs demonstrated 883 options across 2,608 FLDs and 905.28 ha, with a 21.57% yield increase. Additionally, 1,540 demonstrations on 298 maize hybrids and technologies in 432.30 ha showed a 27.50% higher yield compared to farmers' practice.

Millets: Among millets, 277 varietal and technology options were demonstrated on finger millet in 3,071 FLDs by 102 KVKs, resulting in 25.19% yield increase over farmer's practice. Varieties and technologies on pearl millet (95 options), barnyard millet (74), foxtail millet (66), and sorghum (jowar) were demonstrated in 1,710, 174, 438, and 541 FLDs, respectively, yielding average increases of 19.57%, 29.23%, 32.42%, 20.27%, and 27.92% over farmer's practices.

FLD of finger millet variety VL Mandua 376

Pulses: Among the 9,909 FLDs on 2,276 varietal and production technologies for pulses, 2,603 FLDs were conducted on blackgram (24.12% higher average yield), 1,810 on chickpea (21.17% higher yield), 1,613 on lentil (25.04% higher yield), 1,343 on pigeon pea (27.57% higher yield), and 1,243 on greengram (27.02% higher yield) compared to farmer's practices.

Oilseeds: A total of 9,273 FLDs were conducted on 2,801 varieties and management technologies for oilseed crops. Of these, 3,523 FLDs on mustard showed 19.45% higher yield, 1,587 on groundnut showed 19.14% increase, 915 on soybean showed 20.93% increase, and 909 on gobhi sarson showed 19.96% higher yield compared to farmer's practice.

Horticultural crops: Altogether, 21,618 FLDs were conducted on 3,898 varieties and technologies of horticultural crops comprising vegetables (14,014), fruits (3,480), spices (2,194), tuber crops (1,234) and flowers (646), medicinal and aromatic crops (50) in 4,623.40 ha area. The increase in average yields recorded in demonstrations as compared to farmers' practice was 22.77% in vegetables, 28.83% in fruits, 19.32% in spices and condiments, and 20.63% in tuber crops and 24.76% in flowers, over the farmers' practices.

Commercial crops: A total of 463 FLDs including 392 in sugarcane were conducted in an area of 166.66 ha through KVKs. The average yield increase in the demonstrations plots was 13.74% in sugarcane as compared to farmer's practice.

Fibre crops: A total of 1,401 FLDs were conducted on cotton and jute varieties and technologies wherein the average yield was 17.88% higher than the farmer's practice.

Fodder crops: Demonstrations on crops such as berseem, maize, sorghum, Napier grass, etc., were conducted in 3,687 farmers' fields covering an area of 773.8 ha. The average yields in demonstrations were 41.34% higher than the farmer's practice.

Hybrids: To achieve a higher harvest index, KVKs conducted 11,260 FLDs on 2,053 hybrids, covering 3,037.5 ha across cereals, millets, oilseeds, pulses, fodder crops, commercial crops, and horticultural crops. In cereals (rice and maize), 2,262 FLDs were conducted over 687.8 ha to demonstrate hybrid potential. Millets were demonstrated on 574.8 ha, with pearl millet hybrids showing 15.50% higher yield. Castor, mustard, and sesame hybrids yielded 12.38%, 37.86%, and 25.00% higher yields, respectively. Additionally, 4,597 FLDs were conducted on vegetables, fruits, flowers, and spices in 804.5 ha, and 1,202 FLDs on hybrid cotton in 598.60 ha area.

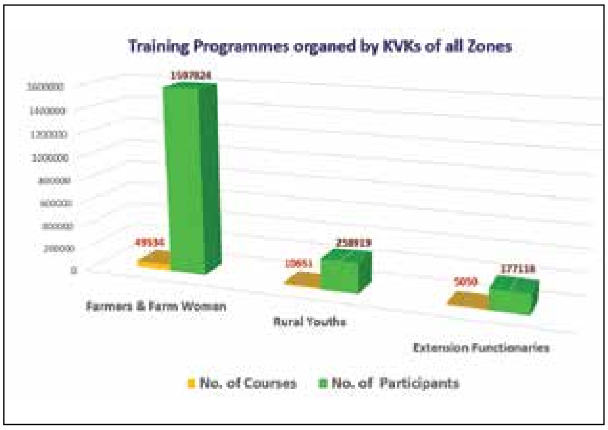
Farm mechanization: A total of 9,089 demonstrations were conducted on 2,643 technology options for improved tools and farm implements, including drudgery reduction technologies, covering 4,880.34 ha. The highest number of demonstrations were on sowing and planting machinery (4,411), followed by plant protection machinery (1,070) and intercultural operation tools and machinery (853).

Livestock and fisheries: The KVKs carried out 17,830 demonstrations on dairy animals, sheep and goat, poultry including chicken, quail, turkey and duck, piggery, rabbit etc., involving 88,526 animals and 2,089 demonstrations on fisheries with 25,49,841 fingerlings.

Enterprises: In all, 17,761 demonstrations on 20 enterprises like mushroom cultivation, apiary, sericulture, value-addition, vermicompost, nursery etc., were conducted in which 24,565 enterprise units were established. On women and children, 10,089 demonstrations were conducted on various enterprises like value-addition, kitchen garden, nutrition etc., for 1,03,514 beneficiaries.

Capacity Development

A total of 20.34 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 65,235 training programmes including the sponsored training courses.



Training programmes organized by KVKs (all zones)

Farmers and farm women: A total of 49,534 training courses benefitted 15.98 lakh farmers and farm women, with 63.83% from other classes and 36.17% from SC/ST categories. The courses focused on enhancing productivity and reducing costs in field crops (22.77%), horticulture (15.98%), plant protection (12.36%), livestock management (9.49%), soil health (9.47%), women's empowerment (12.37%), agricultural engineering (4.68%), group actions (4.99%), input production (3.76%), fisheries (2.50%), and agro-forestry (1.64%). Of the courses, 43.67% were on-campus and 56.33% off-campus. Integrated crop management was the leading theme, with 21.55% of courses, followed by weed management (8.28%) and seed production (7.91%). In horticulture, 50.16% of courses were on vegetables, and 27.61% on fruits.

Rural youth: A total of 10,651 skill development training courses were organized for 2.59 lakh rural youth, including 1,02,928 young women (39.75%). The highest proportion of courses focused on mushroom production (10.52%), followed by value-addition (8.73%), seed production (5.20%), nursery management (6.14%), vermiculture (5.80%), dairying (3.49%), beekeeping (4.89%), integrated farming (5.38%), and organic input production (5.38%). Many other courses covered additional topics in smaller numbers. The majority of these training courses (67.82%) were conducted on-campus.

Extension personnel: A total of 1.77 lakh extension personnel received training through 5,050 courses, with 29.79% female participants. These courses targeted extension functionaries from both government and non-government organizations involved in agricultural development. The training primarily focused on enhancing knowledge in field crops (13.86%), integrated pest management (12.95%), integrated nutrient management (8.91%), protected cultivation (4.10%), information networking (1.17%), and women and child care (3.94%). Other areas included farm animal management, livestock feed and fodder production, ICT applications, and protected cultivation technologies. A larger proportion of the training (66.99%) was conducted on-campus, with the remainder off-campus (33.01%).

Extension Programmes

The KVKs across the country play a vital role in organizing extension programmes to disseminate agricultural and allied sector technologies, bridging the gap between research institutions and farmers. In the reporting year, KVKs conducted 9.33 lakh extension activities, including advisory services (2.72 lakh), diagnostic visits (0.33 lakh), field days (0.12 lakh), group discussions (0.14 lakh), kisan gosthies (0.17 lakh), film shows (0.10 lakh), self-help group meetings (0.03 lakh), kisan melas (0.46 lakh), exhibitions (0.59 lakh), scientist visits (0.78 lakh), health camps (0.04 lakh), farm science club meetings (0.02 lakh), ex-trainee meetings (0.01 lakh), farmer seminars (0.09 lakh), method demonstrations (0.19 lakh), special day celebrations (0.09 lakh), and exposure visits (0.12 lakh). These activities reached 394.57 lakh participants, including 375.02 lakh farmers and 19.55 lakh extension personnel. Additionally, KVKs leveraged electronic and print media, conducting 4.15 lakh extension activities, such as distributing CDs/DVDs (0.02 lakh), extension literature (1.20 lakh), newspaper coverage (0.34 lakh), popular articles (0.05 lakh), radio talks (0.04 lakh), TV programmes (0.03 lakh), animal health camps (0.20 lakh), and other activities (2.26 lakh), benefiting a large number of farmers and stakeholders.

Production of Technological Products

KVKs produced technological products like seeds and planting materials of improved varieties and hybrids, bio-products (bio-agents, bio-pesticides, bio-fertilizers and vermin compost) and elite species of livestock (sheep, goat, pig, rabbit, cow, buffalo and breeding bull), poultry (chickens, quails, ducks and turkey) and fish fingerlings which benefited 31.05 lakh farmers in the country. The details are given in following table.

Details of technological products produced

Products	Quantity	Farmers benefited (No in lakh)
Seeds (lakh quintal)	2.10	11.22
Planting materials (lakh)	550.97	4.80
Bio-products (lakh quintal)	0.49	12.83
Livestock (lakh)	1.22	1.00
Poultry (lakh)	68.23	0.57
Fish fingerlings (lakh)	1184.10	0.63
Total		31.05

Soil, Water and Plant Analysis

KVKs of the country tested 3.80 lakh samples including 3.29 lakh soil samples, 0.36 lakh water samples, 0.14 lakh plant samples and 481 samples of fertilizers, manures, food etc. benefiting 3.77 lakh farmers of 0.49 lakh villages. ₹ 354.92 lakh was realized as analytical charges of which ₹321.04 lakh was from soil testing services. A total of 2.14 lakh Soil Health Cards have been issued to farmers.

Technology backstopping to KVKs: In all, 58 Directorates of Extension Education (DEEs) in SAUs/ CAUs played a pivotal role in technological backstopping to KVKs across the country. During the reporting period, these DEEs organized 729 workshops and meetings to enhance the technical knowledge and capacity of KVK personnel. Additionally, DEE officials conducted 63,622 visits to KVKs, overseeing various activities such as training programs, field days, farmer-scientist interactions, soil health camps, kisan melas/gosthies, technology week celebrations, SAC meetings, animal health camps, diagnostic visits, technology exhibitions, and monitoring the technology dissemination process.

Agricultural Technology Information Centres (ATICs): ATICs (53) serve as a one-stop solution for farmers by offering technological information, advisory services, and agricultural inputs. In the reported period, ATICs supported 3.52 lakh farmers with solutions to their agricultural challenges. They provided farming-related information to 3.28 lakh farmers through both print and electronic channels. ATICs provided 76,762.19 q of disease-free seeds, 14.19 lakh units of improved planting materials, 2 lakh poultry birds, and 31,236.12 q of bio-products to 3.77 lakh farmers. Moreover, 4.61 lakh farmers benefited from various technological services. Additional services included the distribution of 41,833 Soil Health Cards, responding to 1.41 lakh calls via the Kisan Call Centre, offering 8,227 Mobile Agro Advisory services, and organizing 169 special extension programmes.

Special Programmes and Projects

Attracting and Retaining Youth in Agriculture (ARYA): The ARYA project is operational in 100 KVKs. During the year, a total of 694 training programmes were successfully conducted across 24 different enterprises, benefiting 16,952 rural youth (43.46% females) with specialized training. As a result, 3,398 entrepreneurial units were established in various sectors. Each unit generated an average income of ₹ 175,720 and created an average of 190 man-days of employment annually.

National Innovations on Climate Resilient Agriculture (NICRA): The NICRA, a flagship ICAR project launched in 2011, aims to build resilience in agriculture and enhance farmers' ability to cope

Beekeeping unit

Tomato cultivation in Poly-house

Mushroom production unit

Poultry unit

Upscaling of zero tillage maize – Srikakulam, Andhra Pradesh

Capacity building programme on resilient technologies – Bikaner, Rajasthan

Crop diversification with hardy dragon fruit – Lunglie

Winter vegetable production using straw mulch – West Garo hills

with climate stresses (*cf* Chapter 12). Its Technology Demonstration Component (TDC) showcases climate-resilient technologies in project villages, focusing on crop and livestock production systems. The project also establishes village-level institutions such as Village Climate Risk Management Committees, seed banks, and fodder banks to help communities make informed decisions. Currently, the project covers 151 climate-vulnerable districts, with KVKs identifying farming system typologies and addressing local constraints. In the year, 9,458 NRM, 23,139 crop, and 9,893 livestock demonstrations were conducted across 15,100.12 ha. Additionally, 1,878 capacity-building programmes and 3,082 extension activities reached 49,278 and 82,109 farmers, respectively. The focus is shifting towards demonstrating integrated technology packages tailored to specific farming systems, with household-level impact assessments. The project also emphasizes collaboration with ongoing government schemes to extend climate-smart technologies across more villages.

***Mera Gaon Mera Gaurav* (MGMG):** The MGMG initiative aims to foster direct interaction between scientists and farmers to accelerate the lab-to-land process. Its goal is to provide farmers, particularly small and marginal ones, with regular updates, knowledge, and advisory services. During these interactions, farmers raise issues related to technology, loans, market prices, extension programs, and support from various agencies. MGMG is implemented by 113 ICAR institutions and monitored by 11 ATARIs across the country. A total of 994 groups, comprising 3,541 scientists, covered 3,769 villages, conducting 24,484 activities, including awareness campaigns, demonstrations, training sessions, and meetings. Additionally, 17,864 advisories were sent, benefiting 310,137 farmers.

Drone demonstration

Demonstration on Beekeeping

Protected cultivation of King chilli

Remote controlled sensor based direct rice seeder

Farmer FIRST (FF): The Farmer FIRST Programme, a flagship initiative by ICAR, conducted 48,312 demonstrations and organized 3,568 extension programmes during the year. A total of 60,004 livestock and poultry benefited, while 87,382 farm families were covered across all modules. The highest number of demonstrations were held in the Livestock and Poultry module (19,100), followed by the Crop module (12,013), Horticulture (10,838), NRM (4,748), and IFS (3,568). Among the farm families, 15,130 benefited from the Crop module, 11,782 from Horticulture, 12,521 from Livestock and Poultry, 6,008 from NRM, 1,951 from IFS, and 39,990 from extension activities.

Transplanted ragi

Chilli (Arka Haritha) cultivation

Nutrition Sensitive Agricultural Resources and Innovation (NARI): The Nutri-Sensitive Agricultural Resources and Innovations (NARI) Programme, launched

Greengram (MH-421 variety) cultivation

Scientific fish farming

by ICAR, promotes nutrition-sensitive agriculture to combat malnutrition and micronutrient deficiencies. It emphasizes the importance of nutritionally rich foods, dietary diversity, and food fortification, aiming to make the global food system more sustainable and accessible. The programme focuses on increasing the availability and nutritional quality of food through homestead nutrition gardens. KVKs conducted on-farm trials, technology demonstrations, and extension activities under NARI. A total of 13,614 nutri-gardens were established, benefiting 15,774 farm families. Bio-fortified varieties of crops (cereals, millets, pulses, oilseeds, tubers, and vegetables) were demonstrated over 599.88 ha, reaching 2,328 farm families through 1,807 demonstrations. Additionally, 2,312 demonstrations on value addition of various crops were conducted, benefiting 3,746 farm families. KVKs also organized 2,285 training programmes and 2,770 extension activities on nutri-gardens, nutri-thali, bio-fortified varieties, and value-addition. These activities reached 54,723 and 1,07,157 participants, enhancing nutrition literacy and skills.

Demonstration on Nutri-garden

Crop Residue Management (CRM): Punjab, Haryana, and western Uttar Pradesh, the birthplace of the Indian Green Revolution, are key contributors to the national food basket, particularly for paddy and wheat. Due to a narrow 15-25 day window for planting subsequent crops, most farmers in these states burn paddy straw in the field. This widespread burning, occurring over just 15 days, causes significant air pollution, nutritional losses, and soil degradation. To address this, the GoI

Marketing of harvested vegetables of Nutri-Garden

Harvesting of fresh vegetables of Nutri-garden

Value added product of millets

launched the 'Promotion of Agricultural Mechanization for In-situ Management of Crop Residue' scheme in 2018. The ICAR was tasked with implementing the Information, Education, and Communication (IEC) component of this scheme through 60 KVKs in Punjab, Haryana, Delhi, and Uttar Pradesh. Over 56,000 farmers participated in 589 awareness camps at the district, block, and village levels. Capacity building 2,444 farmers, tractor operators, and custom hiring center owners was carried out through 75 five-day training programmes. KVKs also mobilized over 25,000 farmers during 31 kisan melas on crop residue management. Schools and colleges were engaged to spread awareness among students, who in turn encouraged their farming families to adopt modern residue management practices. A total of 27,718 students participated in 204 activities such as essay competitions, debates, and painting contests. Additionally, demonstrations on CRM using machinery were conducted on more than 5,600 ha, and over 1,100 demonstrations on decomposer technology were held. KVKs organized 95 exposure visits and 115 field/harvest days, mobilizing more than 10,900 farmers.

Integrated Farming System (IFS): Around 86% of farmers are small and marginal, and 56% of the population depends on agriculture for their livelihood. Key agricultural challenges include monocropping, limited irrigation, soil acidity, and low-yielding crop varieties. The Integrated Farming System (IFS) was introduced to improve economic sustainability and environmental quality by integrating crops, livestock, and other enterprises. IFS optimizes nutrient use by interlinking different farming components, reducing the need for external inputs. It includes horticulture, agriculture, fisheries, and livestock. During this period, 4,416 IFS demonstrations reached 59,176 farmers, and 4,003 training programmes benefited 96,013 participants.

Cereal Systems Initiative for South Asia (CSISA)

CAR-CSISA collaborative project is being implemented with twin purpose of increasing production of cereal crops (paddy and wheat) through demonstration of improved technologies in eastern Indo-Gangatic Plain and big data management in extension for adoption analytics to provide feedback to research system for reorienting research agenda and providing policy inputs to development departments. Presently adoption data analytics are carried out in pulse crops covering 52 districts of the country.

Achievements under CSISA project 2024-25 under cereals: Nine KVKs demonstrated improved production technologies of paddy in 148 ha and those of wheat in 107 ha. Paddy varieties namely Arize 6444, MTU 7029, BPT 5204 and Rajendra Mahsuri and wheat varieties namely HD 2967 and PBW 373 were favoured by farmers for high yield.

Achievements under CSISA project 2024-25 under Pulses: LDS survey involving 6179 farmers revealed that chickpea variety Awrodhi was still popular while its JG-14 variety was adopted only by 20% pulse growers of Uttar Pradesh. Pulse productivity was low in Jharkhand due to acidic soil and low carbon content in soil. In West Bengal, yield of pulses was low due to high weed infestation.

Formation and promotion of FPOs as CBBOs: A total of 111 Farmer Producer Organizations (FPOs) were formed in 106 blocks across 31 states and union territories, with KVKs acting as Cluster-Based Business Organizations (CBBOs). On average, each FPO has 372 members, with Karnataka and Telangana leading with eight FPOs each, followed by Haryana with seven. Ninety-five FPOs received management cost support and equity grants, with 88 actively engaged in business activities. In addition to working as working as CBBOs, KVKs provided technological support to 3,093 FPOs out of 9,836 nationwide. They organized 3,002 training programmes, benefiting 122,493 members, and supported 848 FPOs in economic activities. Training covered topics like seed production, agronomic practices, off-season vegetable production, value-addition, Integrated Farming Systems (IFS), animal husbandry, poultry rearing, vermicomposting, beekeeping, fish farming, and climate-smart technologies.

Out scaling of Natural Farming through KVKs: The GoI launched a project to scale up Natural Farming practices through 425 KVKs across the country. The project involves awareness, training, and demonstrations, with all 11 ATARIs participating. During the year 4,996 awareness campaigns and 2,243 training programmes were held, reaching 4,49,324 and 99,207 participants, respectively. Madhya Pradesh led with 673 awareness programmes, while Bihar had the most farmers (1,06,508) participating. Gujarat and Madhya Pradesh conducted the most training programmes, with Gujarat training 18,727 farmers. A total of 4,996 demonstrations on natural farming were conducted, with Uttar Pradesh leading (982 demonstrations). Other top states included

Power tiller operated seeder and multicrop reaper

Improved farmer's access to information

Chhattisgarh, Gujarat, Bihar, and West Bengal. Demonstrations focused on cereals, pulses, oilseeds, fruits, and vegetables. Natural farming practices showed varied results: the highest yield increase was 52.47% in vegetables in Kerala and 40% in groundnut in Andhra Pradesh. Yield improvements were also recorded in horticultural crops like tomato in Ladakh (39.50%) and garlic in Nagaland (35.29%). Overall, results were mixed, with positive responses in low-fertilizer regions, and more time may be needed for the technology to fully show benefits.

Agri-drone Project: ICAR is implanting Agri-Drone project, with funding support from Department of Agriculture and Farmers' Welfare, Government of India, with objective of creating awareness among the farmers and other stakeholders and demonstrating the use of drone in agriculture at farmers' fields. The project is being implemented in Agricultural Universities (AUs), KVKs and ICAR Institutions. A total of 15,691 demonstrations were held across 14,975.86 ha in 31 states, focusing on spraying pesticides, weedicides, and nutrients in various field, horticultural, and plantation crops.

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17. Research for Tribal and Hill Regions

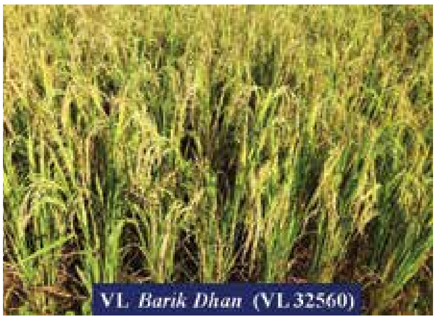
Concerted efforts continued for uplifting the agricultural community in Tribal and Hill Regions through new research, technology transfer and training, under the SCSP, TSP and NEH programmes of ICAR, with initiatives and research focused on breeding, production, and sustainable practices. A total of 14.83 tonnes of breeder seeds from 43 varieties/inbreds of 15 crops were produced, along with 1.21 tonnes of nucleus seed and 24.15 tonnes of Truthfully Labelled (TL) seeds. Eleven new crop varieties, including rice, maize, amaranth, finger millet, and barnyard millet, were released for tribal and hilly regions. These new varieties, such as VL Barik Dhan (rice), VL VitA (maize), and VL Madhurima 1 (maize), exhibit improved yields and disease resistance. Efforts to distribute quality seeds and promote advanced agricultural techniques were also notable. In Chamoli district, 16 polyhouses were established to promote protected cultivation, and training on water management was conducted. Additionally, 140 q of wheat seed were distributed, and 3,200 plants of temperate fruits were provided to 105 tribal farmers. Frontline demonstrations of sweet corn and QPM maize hybrids were carried out, yielding improved results over traditional varieties. In the NEH region, 2,032 kg of seeds from 29 varieties of 14 crops were distributed across eight states. Varieties such as VLQPMH 59 and VLQPMH 45 were provided for demonstration purposes. A participatory seed production programme for finger millet in Arunachal Pradesh involved six farmers. In Tawang, Millet Threshers were demonstrated, and 13 threshers were distributed for community use. Additionally, KVK Sepahijala (Tripura) organized a VL Solar Dryer demonstration and distributed dryers to Self Help Groups (SHGs) to boost income for women farmers. The development of a multi-crop solar house in RRS Leh demonstrated significant improvements in drying apricot and leafy vegetables, reducing drying times considerably. In Nagaland, four Integrated Farming System (IFS) models were developed, showing increased profitability, improved soil health, and sustainability. In the Island and Coastal regions, three animal breeds from the Andaman and Nicobar Islands—Andamani goat, pig, and duck—were officially recognized for their suitability to local conditions. In Minicoy, Lakshadweep, the first Fish Aggregating Device (FAD) was deployed to enhance tuna fishing productivity. Under the TSP, agricultural outreach efforts covered 193 districts, training over 17.9 lakh farmers. These efforts included frontline demonstrations that improved wheat and chickpea yields by 34%. The KSHAMTA programme empowered tribal farmers through nutritious food production and sustainable agricultural practices, benefiting thousands. In Rajouri, Jammu, maize varieties demonstrated under the TSP yielded higher and matured earlier than private-sector hybrids. The construction of solar-powered irrigation systems in Odisha has expanded irrigated areas and significantly increased farmers' incomes while reducing CO_2 emissions. Crop diversification in West Bengal's Chhotanagpur plateau improved yields by 30-45%, benefiting 100 tribal farmers. In Uttarakhand, the Farmers Participatory Seed Production (FPSP) programme helped 54 tribal farmers in Sitarganj's Tharu villages produce 200 q of certified wheat seed, enhancing income and agricultural practices. Similarly, in Vizianagaram, KVK's automated millet and oil processing units empowered 6,200 tribal women, improving their livelihoods and boosting local nutrition and entrepreneurship. These initiatives collectively improved productivity, sustainability, and livelihoods for rural and tribal communities across India.The PRAYAS programme has empowered over 11,261 farmers through targeted interventions addressing issues like quality planting material and livelihood opportunities.

NORTH WEST HIMALAYAS

Breeder seed production: During the period under report, 14.83 tonnes breeder seeds of 43 released varieties/inbreds of 15 crops was produced.

Quality seed production: Around 1.21 tonnes nucleus seed of 31 released varieties of 13 crops was produced following standard methods of maintaining genetic purity. In addition, 24.15 tonnes of Truthfully Labelled (TL) seeds of 23 varieties of 13 crops was produced.

Crop varieties released and notified: Eleven varieties including rice (2), maize (5), amaranth (1), finger millet (2) and barnyard millet (1) were developed



VL *Barik Dhan*

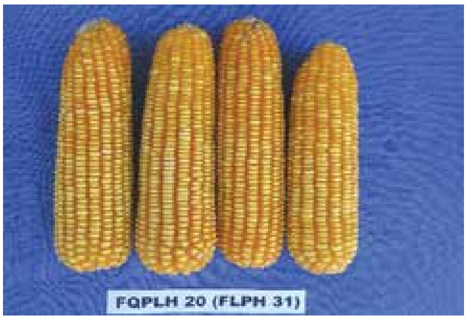
VL *Bosi Dhan*

VL VitA

VL *Madhurima*

VL *Chua* 140

VL *Shikhar*



VL *Triposhi*

VL *Poshika*

VL *Mandua* 409

VL *Mandua* 402

VL *Madira* 254

for tribal areas and hilly region of the country. The details of varieties and their area of recommendations are given here, where as other details about yield and other important traits are given in Chapter 5.

Distribution of quality seeds and technology for improved cultivation: A total of 16 naturally ventilated polyhouses, each measuring 100 m^2, were fabricated on farmers' fields in Parsari and Merag villages of Joshimath block, Chamoli district. A brief training session on 'Protected Cultivation' was conducted at the Farmers Resource Centre, Parsari. Farmer-scientist interactions were organized in Gamshali, Kailashpur, Malari, Jelam, and Parsari villages of the Niti Valley, Chamoli district. Farmers were educated on nutrient management, nursery raising, temperate fruit cultivation, efficient water utilization through drip irrigation, and spring/rainfall water harvesting in hilly regions. All farmers expressed satisfaction with the potato seeds distributed to them, yielding approximately 150 q/ha.

Rice varieties VL Dhan 69 and VL Dhan 88 were demonstrated on approximately 6 ha of farmland in Rajouri, Jammu region, with the assistance of the RARS Rajouri, SKUAST-Jammu. The performance of these improved cultivars significantly outperformed local varieties. Seed production demonstration-cum-farmer participatory seed production of wheat varieties VL *Gehun* 829 and VL *Gehun* 967 was organized in one acre each in Yamunakhadar (Vikasnagar, Dehradun) and total of 19.66 q seed (13.33 q VL *Gehun* 829 and 6.33 q VL *Gehun* 967) was produced.

A total of 140 q seed of different wheat varieties was distributed in Dhanpau-Lakhwad village cluster, Kwanu cluster, and Jammu and Kashmir. In addition, seeds/ planting material of ginger (45 q), garden pea (9.5 q) and onion (25 kg) were also distributed for demonstrations. A total of 3,200 plants of apple, peach, apricot, and walnut etc. were distributed among 105 tribal farmers of Parsari, Merag and Kailashpur villages. In Kailashpur, the production of seeds of VL Bean 2 French bean by seven farmers' SHGs under a participatory model was monitored and a total of 350 kg seed of VL Bean 2 and VL 63 of was procured. Approximately 90% VL Bean 2 seed of last year produce was distributed among 500 tribal farmers of Niti-Mana valley.

Frontline demonstrations (FLDs) of CMVL Sweet Corn Hybrid 1 and VLQPM Hybrid 59 were conducted among 22 farmers in Dadim (2.0 ha) village of district Nainital, Uttarakhand. In the FLDs, the green cob (with husk) yield of VL Sweet Corn Hybrid 1 ranged from 12,620 to 15,290 kg/ha. The average grain yield of VLQPM Hybrid 59 (3,716 kg/ha) was 30.12% higher than the local cultivars (2,856 kg/ha).

North East Hills (NEH)

A total of 2,032 kg seed comprising 29 varieties of 14 crops was supplied to 41 KVKs/institutes across the eight states of North Eastern Hills (NEH) region. Training and seed distribution programmes were organized by KVK Sepahijala (Tripura), KVK Dimapur (Nagaland), College of Agriculture, CAU (Imphal), Ri-bhoi (Meghalaya) and KVK West Sikkim (Sikkim) in collaboration with ICAR-VPKAS, Almora. During the programmes, seeds of VLQPMH 59 and VLQPMH 45 were distributed to the farmers for demonstrations under ICAR-VPKAS NEH programme.

Farmer participatory seed production programme of finger millet variety VL *Mandua* 376 in about 0.6 ha with six farmers was organized in village Bleting, Tawang (Arunachal Pradesh) in collaboration with KVK Tawang.

A Millet Thresher demonstration and distribution programme and Farmer-Scientist interaction was organized at KVK, Tawang in collaboration with KVK, Tawang. The programme was attended by 20 farmers of villages Bleting, Buri, Gipsu, Kharteng, Kitpi, Lumtsang, Namet, Shakti and Shernup. A total of 13 threshers were distributed to the farmers for community use.

A VL Solar Dryer Demonstration and Distribution Programme was organized by KVK Sepahijala (Tripura) at Bishalgarh, Sepahijala in collaboration with ICAR-VPKAS. Dryers were distributed at Bishalgarh, Sepahijala, Tripura in collaboration with Directorate of Extension Education, CAU, Imphal, Manipur and ICAR-VPKAS, Almora. The main motive behind the programme was to show a dryer that can be used for making pickle, drying of spice, condiments, seeds etc., and to enhance the efficiency and income of women farmers associated with Self Help Groups (SHGs). During the programme eight VL Solar Dryers were distributed among eight SHGs with 50 women farmers.

A total of 13 polyhouses were constructed in district Pampumpare and Yachuli (Arunachal Pradesh) in collaboration with the respective KVKs. A meeting was held with the scientists of NRC on Orchids, Gangtok (Sikkim) and officials of Sikkim state departments for identification of sites for construction of polyhouses.

Design, development and performance of multi-crop solar house: A multi-crop solar house is a sustainable and efficient solution for drying agricultural products, especially in regions with harsh climatic conditions. By harnessing solar energy, these structures

Apricot drying under solar house at RRS Leh

Comparative studies on four IFS models

IFS Models	Gross return (₹)	Cost of cultivation (₹)	Net return ₹/unit	Benefit: Cost ratio	Sustainable value index (SVI)
Model 1	1,93,162.80	93,090.60	1,00,072.20	**2.05**	**0.39**
Model 2	1,77,443.50	95,618.75	81,824.78	1.85	0.35
Model 3	1,60,091.00	98,732.60	61,358.40	1.64	0.28
Model 4	2,05,209.70	1,12,850.40	62,501.30	1.80	0.37

Model 1: Horti + Agri+ fishery + piggery + Vermicompost

Model 2: Horti + Agri+ Fishery + Goatery + Vermicompost

Model 3: Horti + Agri+ Fishery + Duckery + Vermicompost

Model 4:Horti + Agri+ Fishery + Poultry + Vermicompost + Mushroom

Four IFS models of Nagaland

can significantly reduce drying time, improve product quality, and minimize post-harvest losses. At RRS Leh, use of multicrop solar house revealed that the maximum temperature gradient on a clear day during winter (December) was 15°C and during summer (August) was about 30°C. Drying of apricot splits was achieved in four days (without auxiliary heating during the night and non-effective sunshine days), as compared to 8-10 days of drying period under open sun drying normally practiced by majority of farmers. Drying of leafy vegetables could be achieved in just 7-8 h.

Integrated Farming System (IFS) models for small and marginal farmers: Four integrated farming system (IFS) models were developed and evaluated in Nagaland. The highest farm profitability was found in model 1 (2.05) followed by model 2 (1.85). Similar was the case with sustainable value index (SVI)**.** Soil health status also recorded to be improved after 5 years by increasing in organic carbon, available nitrogen, phosphorus and potassium. The models have been successfully replicated and demonstrated in major districts of Nagaland.

Island And Coastal Region

Registration of three animal breeds from the Andaman and Nicobar Islands: The Andamani goat, Andamani pig and Andamani duck have been recognised as new breeds. Andamani goats are medium- to short-statured, have a compact body, and are mostly black. These goats are mainly distributed in the Andaman group of islands. Ears are flat and leaf-like, medium-sized, and drooping. Both sexes have small horns, curved upward and backward. The tail is medium in length and curved upward. The body weight at 12 months of age varies from 14 to 19 kg.

Andamani pigs are distributed on different islands in the Andaman group of islands. They are sturdy, medium in size, and black (mostly) or brownish in colour. Neck and back portion hairs are very thick as well as long, whereas hairs on the sides and flank regions are shorter and thinner, respectively. The most commonly observed feature is the slightly downward arch or curvature of the back (low back). They attain a body weight of 60–75 kg for males and 55–65 kg for females at 1 year of age under field conditions. Litter size at farrowing ranges from 6–13.

Andamani duck is a dual-purpose breed, mainly distributed in North and Middle Andaman. They are medium-sized ducks with features such as a comparatively longer neck, a yellowish bill with a black tip, black skin, a white band around the neck, and a shorter shank as compared to other indigenous ducks.

First Fish Aggregating Device (FAD) deployed at 11 nautical miles from Minicoy: The Regional Station (RS) of ICAR-CIARI, Port Blair, located in Minicoy, Lakshadweep Islands, deployed the first Fish Aggregating Device (FAD) at Minicoy to support the livelihood security of the tribal fishing community of Minicoy Islands. The FAD is a floating device designed to attract pelagic tuna species by creating subtle changes in its floating pattern, along with associated attracting devices. It consists of components such as nylon rope, bow shackle, thimble, polyester webbing sling, galvanized swivel, FRP buoy, and concrete block anchor. This technology enhances fish productivity and reduces the time spent searching for fish during fishing operations. The FAD was anchored in the open ocean, 10.5 nautical miles from the shore (Lat: 8° 26' 0.7" N, Long: 73° 11' 0.32" E) in collaboration with the Department of Fisheries on 17 February, 2024.

Tribal Sub Plan (TSP)

A total of 193 districts were identified as the tribal district from across the country where extension activities under TSP were carried out. The activities comprises training on-farm trials (OFTs), frontline demonstrations (FLDs), production of seeds/planting materials/livestock strain/fingerlings, testing of soil, water, plants and manures etc. A total of 9,459 farmers trainings were conducted by the TSP KVKs which were attended by 17,97,193 farmers. In addition,

Andamani goats

Andamani pigs

Andamani duck

Frontline demonstrations in Barwani District of Madhya Pradesh under TSP

4,381 trainings were organized exclusively for 47,334 women farmers. Further, 2,777 and 1,273 trainings were conducted for 43,218 rural youths and 19,660 extension functionaries. A total of 6,165 farmers were involved in OFTs, 32,959 participated in FLD and 24,49,862 mobile agro-advisories were disseminated to the farmers. The production of planting materials, livestock strains and fingerlings comprises 84.44 lakh, 28.28 lakh, 55.77 lakh and also 16,142.16 q seeds were produced all over the country. A total of 26,941 soil, water, and plant manures samples were analysed for the farmers all over India.

The ICAR-Indian Institute of Soil Science, Bhopal in collaboration with KVKs conducted frontline demonstrations (FLDs) at Barwani and Betul district of Madhya Pradesh on wheat (50 farmers) and chickpea (66 farmers) with two interventions, viz., improved practices and farmers practices at farmer's field. Results revealed that the crop yield of wheat and chickpea increased by 34.5 to 34.7% under improved practices over farmer's practice.

Name of crop	Crop yield (kg/ha) under improved practices (IP)	Crop yield (kg/ha) under farmers practices (FP)	Change in yield (%) over FP
Wheat	5,990	4,440	34.7
Chickpea	2,210	1,640	34.5

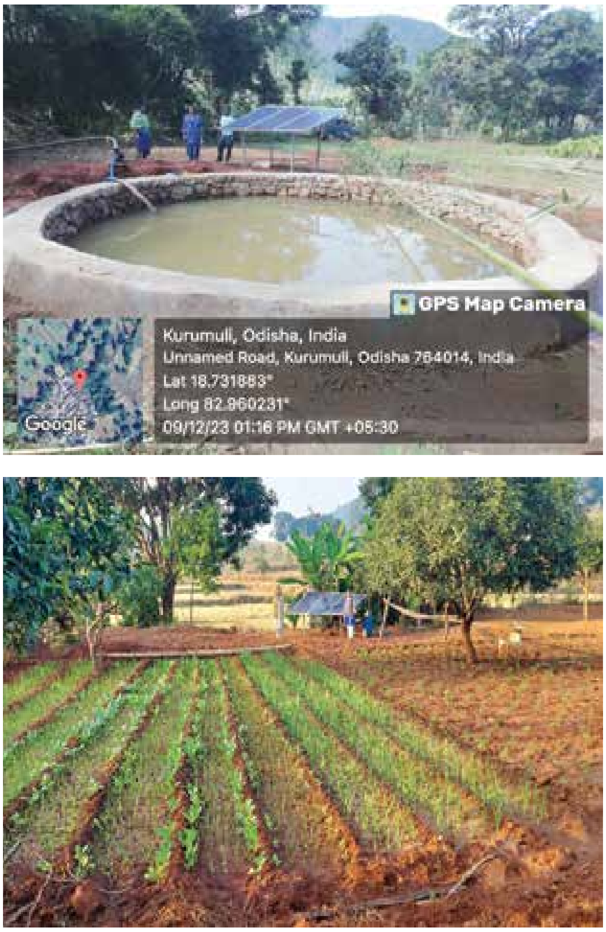
Crop	Crop yield (q/ha)	
	Nutrient management intervention (Farmers' practice + Bioformulations)	Farmers' practice
Soybean	13.2	7.8
Maize	41.7	34.9
Paddy	42.7	37.3

Similarly in 200 tribal farm fields (160 ha) of Betul district in Madhya Pradesh in the third *kharif* season in 2023, bio-formulations were integrated with the farmers' practice. On an average, higher crop yield was observed under improved nutrient management practices.

Knowledge System and Home Based Agricultural Management in Tribal Areas (KSHAMTA): The KSHAMTA programme, implemented by KVKs, aims to empower tribal farmers in growing nutritionally enriching foods through scientific methods. In the reporting year, 79 KVKs conducted various activities across their adopted villages. A total of 511 villages were adopted, where 7,921 demonstrations were held on improved poultry breeds for meat and egg production, edible mushroom cultivation and value-addition, low-cost vermicomposting, and scientific backyard poultry rearing to ensure nutritional security. Additionally, 2,469 training programmes were organized on IFS models, improved pig breeds, bio-fortified maize, nutrition gardens, and agricultural knowledge systems. These activities benefited 8,456 farmers through demonstrations and 76,187 tribal farmers through training programmes, supporting both nutritional security and economic development.

Maize varieties VLQPM Hybrid 45 and VLQPM Hybrid 59 were demonstrated in approximately 5 ha of farmland in Rajouri, Jammu region, under the TSP programme. The Regional Agricultural Research Station (RARS) Rajouri, SKUAST-Jammu, assisted in this demonstration. The variety VLQPMH 45 yielded comparably to the best private-sector hybrid, while maturing about 15 days earlier. The shorter plant height of VLQPM 45 also offers an advantage by reducing the risk of lodging due to heavy rain and wind.

Solar-powered irrigation for sustainable vegetable cultivation: In a significant step towards sustainable agriculture, 60 stone-pitched *Jholakundis* were constructed and equipped with solar-powered irrigation pumps across eight blocks of Koraput district, Odisha, during 2022 and 2023. This initiative, benefiting 51 villages, has revolutionized vegetable cultivation in the region. The new irrigation infrastructure has expanded the irrigated area by 145 ha (84 ha in summer and 61 ha in winter), leading to a substantial increase in cropping intensity from 137% to 272%. Additionally, the mean crop diversification index has doubled, rising from 0.4 to 0.8. The positive impact on farmers' livelihoods is evident, with an impressive four-fold increase in average income, from ₹ 4,644 to ₹ 19,676. Moreover, the adoption of solar-powered irrigation has contributed to environmental sustainability. The 60 solar pumps



Construction of *Jholakundis* and installation of solar operated irrigation pumps in Koraput district of Odisha

collectively reduce CO_2 emissions by an estimated 40,545 kg annually.

Crop diversification in Chhotanagpur plateau of West Bengal: In Chhotanagpur plateau outskirts of West Bengal (Jhargram district), crop diversification has been implemented in rice fallow land by optimizing the packages of practice for lathyrus, mustard, sesame and greengram for *rabi* season in collaboration with Jhargram KVK West Bengal This strategic move has led to a remarkable increase in yield, ranging from 30% to 45% across different crops. Approximately 100 tribal farmers have directly benefited from this initiative. The enhanced net returns, ranging from 29% to 38%, have empowered these farmers and improved their livelihoods.

Schedule Caste Sub Plan (SCSP)

The Scheduled Castes Sub Plan (SCSP) has the objective to ensure flow of targeted financial and physical benefits for the development of Scheduled Castes. At present 34 States/UTs with sizeable SC population are implementing the SCSP activities like training, OFTs, FLDs, extension activities, production of seeds, planting materials, livestock strain, fingerlings, and testing of soil, water, plants and manures etc. A total of 5,189 farmer trainings were conducted by the SCSP KVKs which were

Success Story

Farmers Participatory Seed Production (FPSP) of wheat varieties in the tribal areas of Sitarganj

Farmers in the hills and Tarai region of Uttarakhand faced a significant challenge of acquiring high-quality wheat seeds of newly developed, notified varieties. This hurdle hindered the adoption of these promising crops, which could significantly boost their yields and incomes.

To address this issue, a visionary initiative was launched in 2022-23. Fifty-four farmers from the Tharu tribal villages of Jhankat and Nakulia were selected to become seed growers. These farmers were trained to produce certified, high-quality seeds of four popular and truthfully labelled (TL) wheat varieties developed by ICAR-VPKAS, Almora.

A total of 30 ha of land was dedicated to this Farmers Participating Seed Production (FPSP) programme. The farmers received a variety of wheat seeds, including VL *Gehun* 829, VL *Gehun* 953, VL *Gehun* 967, VL Cookies, VL *Gehun* 2028, and VL *Gehun* 2014.

To ensure the production of high-quality seeds, the farmers received comprehensive training in various agricultural practices. Experts from the institute regularly visited the fields to provide guidance on nutrient management, weed control, disease management, and other best practices.

The impact of this initiative has been remarkable. The farmers successfully produced 200 q of certified TL wheat seed, earning a total of ₹ 5.20 lakhs. The wheat seed was procured at the rate of ₹ 2,600 (2022-23) by the institute, thus giving them a direct benefit over the prevailing MSP by 29.0% (₹ 2,015/q). This not only boosted their income but also contributed to the wider dissemination of these high-yielding wheat varieties in the region.

By empowering farmers to become seed producers, this programme has not only addressed a critical agricultural challenge but also opened up new avenues for rural development and economic growth in Uttarakhand.

Success Story

Empowering tribal women: Arogya Millet Producing Company

In tribal areas, small millets have traditionally been de-hulled manually by women, involving significant drudgery. Due to the lack of proper processing equipment, women often exchange unprocessed grains for low prices with middlemen.

To address this issue, KVK Vizianagaram established a ₹5 crore automated millet processing unit and a ₹2 crore ginger and sesame oil extraction unit in Thumakapalli village, Kothavalasa Mandal, with support from the A P Food Processing Society. The units were designed to benefit tribal farmers and empower women. Under the leadership of tribal woman Mrs K Saraswathi, the units have trained and empowered nearly 6,200 women in millet value-addition and marketing.

The facility produces 14,000 biscuits daily for government organizations like Anganwadi centers and social welfare hostels. With KVK's guidance, the unit creates 20 types of millet products and generates 25 tonnes of foundation seed annually, boosting both millet production and consumption in Vizianagaram. The automated processing equipment has transformed manual millet processing, reducing women's labour burden and promoting value-addition and entrepreneurship.

In addition, a 'Millet Canteen' was set up at the district collector's office to popularize millets among urban communities. Collaborations with the Integrated Tribal Development Agency also raised awareness about improving maternal and child nutrition in tribal areas. Mrs K Saraswathi has received numerous awards for her work, including the "Jayaho Mahila Award" from the Vizianagaram District Police Department, the One MP-One Idea contest cash award from Vice President Shri Venkaiah Naidu, and the Vijaya Laxmi Das FRIOF Women Award from Access Development Services, New Delhi. These initiatives have not only empowered women but also supported the local economy, revived traditional crops, and improved food security and health in tribal communities.

Mushroom Production at Purulia

Goat based Intervention

attended by 1,77,087 farmers. In addition to that, 2,227 trainings were organized exclusively for women farmers which benefitted 47,972 farmers. Apart from that 1,156 and 558 trainings were conducted for rural youths and extension functionaries which aided 26,665 and 17,299 rural youths and extension functionaries, respectively. A total of 3,235 farmers were involved in On-farm Trial, 47,234 participated in Frontline Demonstrations and 13,95,518 mobile agro-advisories were disseminated to the farmers. The production of planting materials,

State-wise major issues and interventions under PRAYAS

Major issues	Interventions	State
Lack of quality planting material, prevalence of rainfed farming	Plantation crops and horticulture based IFS	Assam
Lack of livelihood opportunities, dearth of quality seed and agricultural technologies	Promotion of backyard poultry mushroom for income generation, skilling women and promotions of nutrigarden	Bihar
Majority of rice fallow area, water scarcity, lack of livelihood opportunities	Goat based IFS	Chhattisgarh
Wide knowledge gap regarding advance agricultural practices, lack of improved variety of vegetables	Trainings, vegetable based interventions	Eastern UP
Water scarcity, hilly topography, Wide skill and technology gap	Pig based and horticulture based IFS	Jharkhand
Water scarcity, poor farmers, very low land holdings	Promotion of backyard poultry	Odisha
Lack of marketing facilities, lack of improve varieties of crops and breeds	Mushroom for nutrition and income, poultry, goat and fish based interventions	West Bengal

Backyard Poultry based interventions at Purulia

Chick distribution at Purulia

livestock strains and fingerlings was 51.41 lakh, 91.02 lakh, 127.3 lakh, respectively and also 4,201.03 q seeds were produced all over the country. A total of 75,566 soil, water, plant manures samples were analysed all over India.

Polyhouses and input distribution: Twenty low-cost, small size (62.4 m^2 surface area with 12.0 m length × 5.2 m width × 2.6 m height) VL Portable polyhouses were fabricated for Scheduled Caste (SC) farmers in the Bageshwar district of Uttarakhand. Several inputs like, seeds of improved varieties (1,274.00 kg of cereals and 599.60 kg of vegetables), VL Tool kits (60), VL Polytunnel (77), Battery-operated Knapsack sprayer (14), VL *Mandua* Thresher (10) and Power Tiller (02) were distributed to SC farmers.

Trainings imparted: Hands on training programme was organized for BPL SC farmers of Uderkhani and Lob villages of District Bageshwar, Uttarakhand. Eighteen SC farmers received a polytunnel kit. Simultaneously, a series of hands-on training sessions were organized to familiarize the farmers with the poly-tunnel technology. The training aimed to equip the farmers with practical skills to optimize the benefits of poly-tunnel during the nursery management.

Participatory research application for year-round income and agricultural sustainability: ICAR-RCER Patna's flagship outreach programme, PRAYAS, has empowered socioeconomically disadvantaged communities in 16 villages across 12 districts of seven Eastern Indian states. By implementing targeted technological interventions, the initiative has directly benefited over 11,261 farmers, including 1,172 from Scheduled Castes and 10,089 from Scheduled Tribes.

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18. Organization and Management

The Department of Agricultural Research and Education (DARE), under the Ministry of Agriculture and Farmers Welfare, was established in 1973 and coordinates agricultural research and education in India. It oversees 113 ICAR institutions, 4 CAUs, AgrInnovate India, and the Agricultural Scientists Recruitment Board (ASRB). The ICAR, established on July 16, 1929, is an autonomous organization functioning under DARE. ICAR is led by the Director General, also serving as Secretary of DARE, and is governed by a General Body headed by the Union Minister of Agriculture. The organization oversees a vast research network, including 113 institutes, 82 coordinated research projects, and 77 agricultural universities. ICAR's responsibilities encompass agricultural research, education, and extension activities. The research set up of the ICAR include 74 Research Institutes, 6 National Bureaux, 11 Project Directorates, 11 Agricultural Technology Application Research Institutes (ATARIs), and 11 National Research Centres (NRCs). In addition, there are 82 All India Coordinated Research Projects (AICRP) and All India Network Projects (AINP). The Directorate of Knowledge Management in Agriculture (DKMA), New Delhi, functions as the communication arm of ICAR. The Technical Coordination Unit of ICAR supports by preparing monthly Cabinet summaries, organizing meetings, and managing financial assistance for scientific societies. It coordinates with various national bodies and handles references from the Prime Minister's Office and Parliament. In 2024-25, it provided financial support to 44 societies for publishing scientific journals and facilitated 59 national and international conferences. Sixty Umbrella MoUs were signed with universities to bolster collaborative research. Under the Swachh Bharat Mission, it implemented projects such as agricultural waste management, fish waste utilization, and sewage water treatment, with ₹350 lakhs spent in 2023-24 and ₹400 lakhs earmarked for 2024-25. Campaigns like Swachhta Hi Sewa and Special Campaign 4.0 focused on file management, freeing 97,579 sq. ft. of space and generating ₹8.28 lakh in revenue. ICAR's 96th Foundation Day was marked by technology launches, exhibitions, and awards. It facilitated review of 43 ICAR Institutes, while promoting technological advancements through reports submitted to government bodies. Grants were released for ICAR-Norman Borlaug and Lal Bahadur Shastri Outstanding Young Scientist Awards after project evaluations. The unit also actively coordinated Swachhta Action Plan activities, monitored progress, and uploaded reports to designated portals. Its initiatives, including organizing review meetings with the Agriculture Minister and inter-ministerial assignments, contribute significantly to ICAR's vision of advancing agricultural research, education, and sustainable practices.

Department of Agricultural Research and Education

The Department of Agricultural Research and Education (DARE) was created within the Ministry of Agriculture, Government of India (GoI), in December 1973 to oversee and promote agricultural research and education nationwide. DARE facilitates essential government connections for the Indian Council of Agricultural Research (ICAR), the leading research body responsible for coordinating, guiding, and managing research in areas such as crop science, horticulture, natural resource management, agricultural engineering, animal science, fisheries, education, and extension services across India. With 113 ICAR institutions and 77 agricultural universities across the country, it represents one of the largest national agricultural research, education, and extension systems (NAREES) globally.

In addition to ICAR, DARE oversees several other autonomous organizations, including the Central Agricultural Universities (CAUs) in Imphal (Manipur), Jhansi (Uttar Pradesh), and Pusa (Bihar), as well as AgrInnovate India Limited in Delhi. Established on October 19, 2011, AgrInnovate India Limited leverages the strengths of DARE and ICAR to promote and disseminate research and development outcomes. It functions as an independent commercial entity, designed to capitalize on the extensive ICAR network, where researchers work to innovate and apply science to ensure access to food, nutrition, livelihood, and income security. The Agricultural Scientists Recruitment Board (ASRB) is another attached body of DARE. The ASRB plays a key role in recruitment of best quality scientists and other management personnel for ICAR and its research institutes across the country. In addition, the Board aids and advise the Council in evolving and implementing policies related to induction of human resource and its development including the Career Advancement

Schemes for ARS Scientists.

Indian Council of Agricultural Research

The ICAR is an autonomous organization under the DARE, Ministry of Agriculture and Farmers Welfare, Government of India. Formerly known as the Imperial Council of Agricultural Research, it was established on 16 July 1929 as a registered society under the Societies Registration Act, 1860 on the recommendations of the Royal Commission of Agriculture. It was reorganized in 1965 and again in 1973, with its Headquarters located in Krishi Bhawan, New Delhi, alongwith support facilities in Krishi Anusandhan Bhawan (KAB) 1 & 2 and NASC Complex, Pusa, New Delhi. The Union Minister of Agriculture and Farmers Welfare is the President of ICAR. The Principal Executive Officer of the ICAR is the Director General, who also functions as Secretary, DARE, GoI. The General Body of the ICAR Society, headed by the Union Minister of Agriculture and Farmers Welfare is the supreme authority of the ICAR. Its members include; Ministers for Agriculture, Animal Husbandry and Fisheries, and the Senior Officers of the various State Governments, Members of Parliaments and the representatives from industry, research institutes, scientific organizations and farming community.

The Governing Body (GB), headed by Secretary, DARE and DG, ICAR is the chief executive and decision making authority. The GB consists of eminent agricultural scientists, educationist, public representatives and farmer representatives. It is assisted by the Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and Publications Committee. In scientific matters, the DG is assisted by eight Deputy Director Generals (DDGs), one each in Subject matter Divisions (SMD) of (i) Crop Science, (ii) Horticultural Sciences, (iii) Natural Resource Management, (iv) Animal Science, (v) Agricultural Engineering, (vi) Fisheries Sciences, (vii) Agricultural Education, and (viii) Agricultural Extension. The DDGs are the Heads of respective SMD for the entire country, and supported by Assistant Director Generals (ADGs). The SMDs are responsible for extending all technical and financial guidance as well as support to the research Institutes, National Research Centres and the Project Directorates within their respective SMD. In addition, ADGs of National Agricultural Science Fund (NASF), Coordination, Plan Implementation and Monitoring (PIM), Intellectual Property & Technology Management (IP&TM) also assist the DG in their respective job roles.

The research set up of the ICAR include 113 institutes comprising 74 Research Institutes, 6 National Bureaux, 11 Project Directorates, 11 Agricultural Technology Application Research Institutes (ATARIs), and 11 National Research Centres (NRCs). In addition, there are 82 All India Coordinated Research Projects (AICRP) and All India Network Projects (AINP). The Directorate of Knowledge Management in Agriculture (DKMA), New Delhi, functions as the communication arm of ICAR, responsible for delivering information and knowledge generated by ICAR and its institutions, through publications, information management, social media, and public relations unit. The ICAR also promotes research, education and frontline extension activities through 77 Agricultural Universities, which include 66 State Agricultural Universities, 4 Deemed-to-be-Universities, 3 Central Agricultural Universities, and 4 Central Universities with agricultural faculty by giving financial assistance in different forms.

Technical Coordination

The Technical Co-ordination Unit is mandated for preparation of monthly Cabinet Summary for Cabinet Secretary, organizing meeting of 'Standing Committee' for grant of financial assistance to Scientific Societies and Academic Institutions for holding of National/ International Conferences/Seminars and publication of Scientific Journals; organizing Directors Conference, coordinating the ICAR Regional Committee Meetings, collaboration with DST, DBT, CSIR, ICMR, Bureau of Indian Standards etc. One of the major role of the Unit is to deal with the references received from Prime Minister's Office, President's Secretariat, Members of Parliament and other VIPs; laying of ICAR Annual Report and Audited Accounts in the Parliament, formulation and submission of responses to Parliament Questions. The Unit acts as the nodal point for e-Samiksha portal for DARE/ICAR. Guidelines for Krishi Awards are formulated and revised suitably from time-to-time. Releasing funds for Lal Bahadur Shastri (LBS) and Norman Borlaug Award projects, handling and promotion of the Swachhta Action Plan (SAP) are also undertaken. It is also involved in providing inputs for agenda items and compilation of information for Zonal Council Meetings organized by Ministry of Home Affairs; organizing the Review Meetings of ICAR Institutes under the Chairmanship of Hon'ble Union Agriculture Minister and taking up various campaigns from Central Government Schemes and their convergence on behalf of ICAR.

ICAR's Directors Conference and Annual Conference of Vice Chancellors

The ICAR's Directors Conference and Annual Conference of Vice Chancellors was organized during 26-27 February, 2024 at Bharat Ratna Dr. C Subramanian Auditorium, NASC Complex, Pusa, New Delhi. The Conference was organized in physical mode and inaugurated by Dr Himanshu Pathak, Secretary, DARE and DG, ICAR in the presence of Dr Sanjay Kumar, Chairman ASRB, and all DDGs and other senior officers of ICAR. Dr Pathak highlighted that lCAR is working tirelessly for strengthening and development of higher agricultural education in India. He highlighted the significant milestones achieved in the

Green, White, Blue, Yellow, Golden, Silver, Brown and Grey Revolutions. These revolutions have collectively transformed Indian agriculture, leading to a remarkable increase in production since 1970 within the same net sown area. The resilience of food production over the years was emphasized, showcasing the sector's ability to adapt and thrive. Dr Pathak stressed the need for reorienting the NAREES. Emphasizing the necessity of rightsizing ICAR to enhance efficiency, he proposed the "7Cs" approach, which includes Consortia research, Collaborative research, Contract research, Consultancy research, Commercialization, Costing Academics, and Constructing Research facilities. Additionally, the potential of Public-Private Partnerships (PPP) was highlighted as a means of generating resources for the organization.

Regional Committee Meetings

The Regional Committee Meetings (RCM) held once every two years, provide an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. It provides a forum for liaison and coordination among the ICAR institutes, State Agricultural Universities (SAUs) and State's Line Departments (Agriculture, Horticulture, Animal Husbandry and Fisheries etc). Secretaries of State Department, Members of ICAR Governing Body, Senior Officials from ICAR Headquarters and State Departments, Vice-Chancellors of SAUs, Directors and Scientists of ICAR Institutes in the region participate in the meeting, which is chaired by Secretary, DARE and DG, ICAR. The problems being faced by the states in areas of agriculture and related fields and the technological options/potential solutions available or to be developed by the NARS system are discussed threadbare. During 2024, three RCM were organized (ICAR Regional Committee No. VIII on 16 Feb at ICAR-CIBA, Chennai; ICAR Regional Committee No. II on 23 August at ICAR-NRRI, Cuttack and ICAR Regional Committee No. IV on 14 November at ICAR-IISR, Lucknow). Hon'ble Agriculture Minister, Hon'ble Minister for Animal Husbandry, Dairying and Fisheries and Hon'ble Minister of State for Agriculture provided their valuable suggestions in the meetings through video conferencing. Actionable points were identified and assigned to the respective ICAR institutes/SAUs /CAUs/ KVKs to be resolved in a targeted time frame. The action taken on the issues raised in the previous RCM were also reviewed.

ICAR Foundation Day

The 96th Foundation and Technology Day of ICAR was celebrated during 15-16 July 2024. During the occasion, certificates for five new technologies per SMD along with the release of related products and books were presented. The winners of Hackathon were awarded and a three-day exhibition was organized. During the celebration, around 500 farmers and 500 school children, in addition to senior officers of ICAR and other Departments, visited the exhibition. Sh. Shivraj Singh Chauhan, the Hon'ble Union Minister of Agriculture & Farmers Welfare and President of the ICAR Society, extended congratulations to ICAR and the dignitaries on this significant occasion. Union Minister for Fisheries, Animal Husbandry and Dairying; Shri Rajiv Ranjan Singh (alias Lalan Singh); Union Ministers of State for Agriculture and Farmers' Welfare; Shri Bhagirath Chaudhary and Shri Ram Nath Thakur; Union Minister of State for Fisheries, Animal Husbandry & Dairying and Minority Affairs, Shri George Kurien and Union Minister of State for Fisheries, Animal Husbandry & Dairying and Panchayati Raj, Prof. S.P. Singh Baghel were also present on the occasion.

After the Award Ceremony, grants to the awardees of ICAR-Norman Borlaug and ICAR-Lal Bahadur Shastri Outstanding Young Scientist Award were released and regular performance monitoring is being done. The working and future planning of ICAR Institutes were reviewed by the Hon'ble Union Minister of Agriculture & Farmers Welfare. Total 43 reviews were conducted for 15 Institutes of Crop Science SMD, 20 Institutes of Horticultural Science SMD, 3 Institutes of NRM SMD, 3 Institutes of Agricultural Engineering SMD and 2 Institutes of Animal Science SMD.

Reporting to Parliament and Ministries/Departments

The Annual Report of ICAR for the 2023-24 along with review statement was laid on the table of Lok Sabha on 30 July, 2024 and Rajya Sabha on 2 August, 2024. Further, the Annual Account and Audited Report of ICAR for the 2022-23 along with the review statement was also tabled in Lok Sabha and Rajya Sabha on 30 July and 2 August, 2024, respectively (well before time).

Monthly information on New Emerging and Strategic Technologies from all SMDs was collated and after approval from Competent Authority, the same was submitted to the Ministry of External Affairs. Additionally, quarterly data on women's participation was provided to the Department of Women and Child Welfare, while monthly updates on the ease of doing business from all SMDs were shared with the Department for Promotion of Industry and Internal Trade (DPIIT).

The Swachhta Action Plan (SAP) was communicated to all ICAR establishments and progress reports for three quarters were compiled and uploaded to the designated SAP Portal (https://swachhataactionplan.gov.in/swachta/). A total of ₹350 lakhs were sanctioned for SAP activities in FY 2023-24, with ₹400 lakhs allocated for FY 2024-25. *Swachhta Hi Sewa* (with the theme *'Swabhav Swachhata – Sanskaar Swachhata'*) was observed from 15th September to 1st October 2024, along with *Swachh Bharat Diwas* on 2nd October 2024. These events were celebrated across all ICAR Institutes, KVKs, and establishments, with a date-wise action plan shared for implementation as per the guidelines of the

Department of Drinking Water & Sanitation, Ministry of Jal Shakti. Daily reports were uploaded on the designated portal and ICAR website.

DARE/ICAR actively participated in Special Campaign 4.0 (October 2-31, 2024) led by the Department of Administrative Reforms & Public Grievances, GoI. The campaign focused on record and space management, including weeding out physical and electronic files, promoting Swachhata awareness in villages, and improving workplace conditions. During the campaign, 7,000 physical files and 2,000 e-files were reviewed, freeing up 97,579 square feet of space and generating ₹8,28,009 in revenue.

Memoranda of Understanding

A total of 60 Umbrella Memoranda of Understanding (UMoU) were signed between the ICAR and other Host Institutions, i.e. Central Universities/CAUs/SAUs to co-operate in conducting research through All India Coordinated Research Projects (AICRPs) and any other such schemes funded/sanctioned by the Council from time-to-time at specified location(s).

Support to Scientific Societies

During the Fiscal year 2024-2025, the ICAR provided financial support to 44 societies for the publication of various scientific journals. In addition, societies/associations/universities were supported for holding 40 National Seminars/Symposia/Conferences and 19 International Seminars/Symposia/Conferences.

Administration

Filling up of vacant posts

During the period, following posts were filled up in ICAR under the promotion quota: 4 Director/CAO (Senior Grade), 1 Deputy Director (F)/CFAO, 4 Deputy Secretary/CAO, 3 Senior Finance and Accounts Officer, 6 Under Secretary, 7 Senior Administrative Officer, 6 Administrative Officer, 2 Finance and Accounts Officer, 6 Principal Private Secretary, 2 Finance and Accounts Officer, 7 Section Officer, 52 AFAO, 2 Private Secretary and 3 Personal Assistant at ICAR Headquarter. Under the direct recruitment (DR) quota, 35 posts of AO and 29 posts of FAO were filled up. Institute-wise allocations have also been made for 806 posts of Assistant at ICAR through DR Examination.

Financial upgradation granted under MACP Scheme

During the period under report, 33 eligible officers and staff of ICAR were granted the benefits of financial upgradation under the Modified Assured Career Progression (MACP Scheme).

Finance

The Revised Estimates in respect of DARE/ICAR for 2023-24 was ₹ 9,876.60 crores. An internal resource of ₹ 499.72 crores (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2023-24. The total allocation Budget Estimates for 2024-25 is ₹ 9,941.09 crores.

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19. Intellectual Property and Technology Management

National Agriculture Innovation Fund (NAIF)

Intellectual Property (IP) Protection

Patents: During the reporting period, a total of 143 new patent applications were filed across various domains of agricultural sciences at the Indian Patent Office (IPO). These included applications in Crop Science (40), Animal and Fisheries Science (27 each), Horticulture Science (20), Agricultural Engineering (14), Agricultural Extension (4), and Agricultural Education (1). A total of 64 ICAR institutes contributed to this effort to safeguard their innovations. As a result, the cumulative number of patent applications filed by ICAR has now reached 1,706. The IPO granted 125 patents in areas such as Chemicals, Biotechnology, Food, Agricultural Engineering, Agrochemicals, Microbiology, Biochemistry, and Traditional Knowledge, bringing ICAR's total number of granted patents to 678.

> The ICAR's overall IP portfolio has increased by 22.24% over the past two years. This growth has raised the cumulative total of IPR applications to 4,818.

Plant varieties: To safeguard plant varieties, a total of 83 applications (75 for existing varieties and 8 for new ones) were submitted to the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA) across 28 crop species from 15 ICAR research institutes. During this period, registration certificates were granted for 19 previously filed varieties. As a result, the cumulative total of plant variety protection applications reached 1,562.

Copyrights: A total of 307 copyright applications were filed by various ICAR institutes, categorized as follows: 13 for Artistic works, 21 for Cinematograph Films, 92 for Computer Software, and 181 for Literary/Dramatic works. This brings the cumulative total of copyright applications filed by ICAR institutes to over 800.

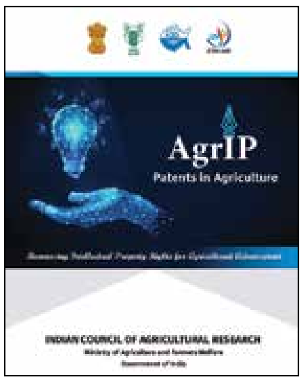
Design: A total of 120 design applications were filed by 39 ICAR institutes across 27 design classes, bringing the cumulative total to 225 applications. The majority of applications (32) were submitted in the Agricultural and Forest Machinery category, representing the most active area of innovation.

Trademarks: A total of 111 trademark applications were submitted by 37 ICAR institutes for various products and processes across 25 classes of goods and services. Of these applications, 50% have been successfully registered, while the rest are still being processed. To date, ICAR has filed a total of 344 trademark applications.

Capacity building activities: To promote awareness in the field of innovation management and technology transfer, various ICAR institutes have organized capacity-building programmes at the institute, zonal, and national levels. A total of 71 ICAR institutes conducted 177 programmes, including awareness sessions, interface meetings, product-specific workshops, seminars, and more. These initiatives benefited 2,620 scientists, researchers, business professionals, farmers, and social workers. Additionally, to enhance the knowledge of scientific and technical staff on intellectual property and technology management, 201 personnel were sent to attend capacity-building programmes organized by both public and private organizations. Some key initiatives include:

Industry Meets/Business Meets: To showcase ICAR's technology portfolio and bridge the gap between industry and academia, 15 institute-specific industry/stakeholder meetings were organized across various sectors. These included fruit and vegetable production (ICAR-CISH, Lucknow; ICAR-CIAH, Bikaner; ICAR-CITH, Srinagar; ICAR-IIHR, Bangalore), seed and planting material (ICAR-IIRR, Hyderabad; ICAR-DRMR, Bharatpur; ICAR-IISR, Indore; ICAR-IIOR, Hyderabad), animal-based products and processes (ICAR-CSWRI, Avikanagar; ICAR-NRC on Mithun, Jharnapani; ICAR-NMRI, Hyderabad), food processing (ICAR-CIPHET, Ludhiana), and natural resource management (ICAR RC for NEH, Barapani; ICAR-IISWC, Dehradun), among others.

AgrIP-I: Certificate Course on Patents: A one-month specialized 'Certificate Programme on Patents in Agriculture' was conducted to support ongoing patent filing activities at the institute level, organized by the IP&TM Unit in collaboration with its ZTMC at ICAR-CIFT, Cochin. Additionally,



AgrIP, an online short course on 'Patents in Agriculture', was held from 15 January to 15 February 2024, with 172 participants who successfully passed the final exam. To cover all major aspects of agricultural patents, 18 subject-specific sessions were organized under the leadership of ICAR Directors, with key speakers invited from various national public and private organizations.

World Intellectual Property Day: All Institute technology Management Units (ITMUs) celebrated World Intellectual Property Day on 26 April 2024, in alignment with the World Intellectual Property Organization's (WIPO) theme, "IP and the SDGs: Building our common future with innovation and creativity." This day provided an opportunity to emphasize the significance of intellectual property rights, including patents, copyrights, designs, trademarks, and plant varieties, in fostering innovation and creativity within the scientific community of the Council.

Online Review of NAIF Initiatives: Online reviews were conducted to assess the status of the IP portfolio and business incubation efforts at ITMUs and Agri-Business Incubation Centers (ABICs). These reviews revealed that substantial capacity-building initiatives are necessary for both areas. As a result, programmes such as SAMAGRA, SRIJAN, SAMIKHSA, and SANDARBH were introduced to address these needs.

SRIJAN-I and II: Empowering the ITMUs/ZTMUs: Sensitization workshops were organized to raise awareness about innovation processes and their feasibility, as well as to discuss the IP portfolio and ecosystem in the country and its relevance to the ICAR system. These workshops were attended by all PIs/Co-PIs of ITMUs/ZTMUs. The Secretary, DARE and DG, ICAR, dedicated valuable time to these sessions, addressing each aspect of the three-tier IP system. Their discussions led to the issuance of clarifications on Technology Licensing within the Council.

SAMIKSHA: The Quarterly Review Meetings (QRMs) for the National Agriculture Innovation Fund (NAIF) project activities, under its Innovation Fund (ITMUs/ZTMUs), were held to evaluate budget requirements and their need-based allocation. The meetings also focus on reviewing targets, identifying next steps for IP and outreach initiatives, updating IP portfolios, tech-transfer efforts, and capacity-building data. Additionally, the meetings facilitate coordination for IP filing and publications, while exploring new opportunities and addressing various management aspects.

SANDARBH: The purpose of QRMs of NAIF project activities under Incubation Fund for ABICs was to assess the budget requirements and its need-based allocation; target reviews, and way forwards for entrepreneurship/start-up and outreach initiatives; Incubatee registration and their graduation; Entrepreneurship Development Programmes (EDPs); coordination for business incubation programmes and publications; and also, to discuss about new avenues and other management aspects.

IP Week: To raise comprehensive awareness about intellectual property (IP) and related topics among the Council's scientists, technical staff, scholars, and contractual employees, the IP&TM Unit, in collaboration with its ITMUs, organized a five-day online awareness programme. During these IP-Week, scientists from five to six ICAR institutes (focused on similar subjects) were trained together on various IP tools, including copyrights, designs, patents, plant varieties, trademarks, geographical indications (GI), and technology licensing, with guidance from specialized experts. Certificates were awarded to all participants upon completion of these sessions. In the reported period, eight such IP Weeks and two panel discussions were held, engaging over 600 participants from NRM and Horticulture Science institutes. Experts for these sessions were invited from various government institutions, universities, IPR attorneys, and in-house professionals.

Technology transfer/commercialization: The

period also witnessed increasing involvement of ICAR institutes in technology licensing activities with public and private sector organizations for partnerships in research and technology commercialization.

Technology Licensing: This year, 1,012 partnership agreements were established with 586 public and private organizations and 50 farmers/entrepreneurs. A total of 63 ICAR institutes, representing various Subject Matter Divisions, participated in the process, transferring 412 technologies across different disciplines. These included: Animal Health and Production Technologies (52); Crop Production Technologies (24); Farm Machinery and Tools (36); Fish Farming and Processes (27); Food Processing Technologies (69); Plant Protection Technologies (26); Seed and Planting Material (172); and six technologies from allied sectors. The top 20 technologies, such as wheat variety HD 3406 (43 agreements), DBW 327 and HI 1650 (29 each), and black pepper variety IISR Chandra (15), were transferred through 258 licensing agreements. Of the 1,012 partnerships, 471 (46.54%) involved IP-protected technologies, including those registered under Design/Patents/Trademarks/Copyrights/PPV&FR registry.

Professional Service: This year, 72 partnership

agreements were signed for Consultancy/Contract Research and Services with 67 public and private organizations. A total of 10 ICAR institutes from various Subject Matter Divisions participated in providing a range of professional services during this process.

Incubation Fund

To foster the agri-business environment at the Council, 50 Agri-Business Incubation (ABI) Centers have been established across various institutes to support entrepreneurs, innovators, scholars, and start-ups. During the reporting period, these centers assisted 838 stakeholders in their business incubation activities. As a result, 214 entrepreneurs/start-ups were encouraged to launch their own businesses. Additionally, 181 Entrepreneur Development Programmes (EDPs) were organized by these centers, benefiting various stakeholders. To strengthen partnerships with public and private organizations, 361 meetings, negotiations, and technology discussions were held. Over 3,000 technology seekers, inventors, business people, VIPs, and international visitors also visited these centers.

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Partnership and Linkages

The International Relations Division (IRD) of ICAR manages and coordinates international cooperation in agricultural research, education, and extension, with ICAR, DARE and various national and international organizations like the Ministry of External Affairs, Ministry of Commerce, and the Department of Biotechnology. The IRD oversees bilateral and multilateral collaborations, facilitating partnerships through Memoranda of Understanding (MoUs), joint research projects, and work plans with global institutions. This year, under bilateral cooperation, 29 MoUs were processed across 26 countries. Notable partnerships include those with Western Sydney University, WorldFish, ICRISAT, and the World Vegetable Center. ICAR also collaborated extensively with the Consultative Group on International Agricultural Research (CGIAR), regularly reviewing progress on joint research efforts. Multilateral cooperation was achieved through participation in global forums like G-20, ASEAN, BRICS, and QUAD. Key 2024 events include the 1st BRICS Agricultural Cooperation Working Group meeting, BIMSTEC Workshop on Agricultural Trade and Investment, and ASEAN-India agricultural meetings. Furthermore, ICAR launched the ASEAN-India Fellowship for agricultural education and the AI-ENGAGE initiative under QUAD, which focuses on precision agriculture using AI and robotics. The IRD also facilitates the exchange of knowledge and technology by organizing visits from foreign delegations. A total of 125 foreign delegations visited ICAR headquarters and research institutes, promoting collaboration and showcasing India's agricultural advancements. Through these diverse initiatives, ICAR strengthens its role as a global leader in agricultural research and sustainable development.

The International Relation Division (IRD) was established in 2014 at ICAR Headquarters as a single-window interface for coordinating international cooperation on agricultural research, education, and extension. It facilitates interactions between ICAR, the Department of Agricultural Research and Education (DARE), and other national and international bodies, including the Ministry of External Affairs, Ministry of Commerce, and Department of Biotechnology. The IRD manages bilateral and multilateral collaborations through Memoranda of Understanding (MoUs), work plans, and joint research projects with foreign governments, institutions, and organizations. It organizes international delegation meetings and visits to ICAR Headquarters and institutes, promoting dialogue and partnerships. The division ensures ICAR's research priorities align with global advancements and emerging agricultural technologies, fostering innovation and competitiveness in Indian agriculture. Through these efforts, ICAR strengthens its position as a global leader in agricultural science and sustainability.

Bilateral cooperation

ICAR/DARE has established robust international cooperation mechanisms under Government of India provisions, facilitated through MoUs and Work Plans. In 2024, 29 MoUs from 26 countries were examined, processed, and submitted for multi-ministerial clearance

Dr Himanshu Pathak, DG (ICAR) and Dr Jacqueline D'Arros Hughes, DG (ICRISAT) signed the Work Plan between ICAR and ICRISAT on July 5, 2024 at New Delhi

The MoUs are implemented through Work Plans. An MoU between ICAR and University of Melbourne, Australia was signed in 2024 for cooperation in agricultural research and education.

Organization	Workplan duration	Signed on
Western Sydney University, Australia	2024-2029	6th March 2024
WorldFish, Malaysia	2024-2028	28th June 2024
ICRISAT, Hyderabad, India	2024-2028	5th July 2024
World Vegetable Center, Taiwan	2024-2026	14th October 2024

The ICAR has maintained a longstanding collaboration with the Consultative Group on International

Agricultural Research (CGIAR), advancing research through well-planned work agreements. On February 6, 2024, the progress of research collaborations with 11 CGIAR centers was reviewed under the chairmanship of Dr. Himanshu Pathak, Secretary (DARE) and DG (ICAR). The meeting was attended by ICAR officials, including DDGs, ADGs, and Directors of various ICAR Institutes, as well as CGIAR Country Representatives and their teams. The research progress made by CGIAR centers in 2023 was commended.

H.E. Shri Bhagirath Choudhary, Honorable Minister of State for Agriculture and Farmers Welfare, Government of India co-chaired the 8th ASEAN-India Ministerial Meeting on Agriculture and Forestry held on 25 October 2024.

Multilateral Cooperations

Multilateral cooperation is facilitated through international forums such as G-20 Association of Southeast Asian Nations (ASEAN), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC); South Asian Association for Regional Cooperation (SAARC); Brazil, Russia, India, China, and South Africa (BRICS); QUAD and Asia Pacific Association of Agricultural Research Institutions (APAARI).

- In 2024, the 1st Meeting of the BRICS Agricultural Cooperation Working Group was held on April 16-17, featuring a presentation on the BRICS Agricultural Research Platform (BARP).
- Dr. R. C. Agrawal and Dr. Seema Jaggi from the ICAR Education Division participated in the BIMSTEC Second Workshop on Agricultural Trade and Investment on December 24, 2024, where they presented a status paper on Agricultural Research, Extension, and Education in India.
- The 9th ASEAN-India Working Group Meeting on Agriculture and Forestry was held on August 8, 2024, in Johor Bahru, Malaysia. Dr. A. K. Misra from the IR Division presented progress on the Medium Term Action Plan supported by ICAR and discussed issues to strengthen ASEAN-India agricultural partnerships.
- The Preparatory Senior Officials Meeting for the 8th ASEAN-India Ministerial Meeting on Agriculture and Forestry was held on October 23, 2024, via video conference, with participation from all ASEAN Member States (AMS), India, Timor Leste as an observer, and the ASEAN Secretariat. The meeting was co-chaired by Myanmar and India.
- The 8th ASEAN-India Ministerial Meeting on Agriculture and Forestry (8th AIMMAF) took place on October 25, 2024, via video conference. It was co-chaired by H.E. Min Naung, Union Minister of Agriculture, Livestock and Irrigation of Myanmar, and H.E. Shri Bhagirath Choudhary, Honorable Minister of State for Agriculture and Farmers Welfare, Government of India.
- ICAR launched the ASEAN-India Fellowship for higher education in agriculture and allied sciences on August 14, 2024, for the benefit of students from ASEAN member states. A total of 50 fellowships will be awarded to ASEAN students over the next five years to pursue Master's degrees at top Indian universities and Agricultural Universities under ICAR.
- The Advancing Innovation for Empowering NextGen Agriculture (AI-ENGAGE) initiative was launched under QUAD cooperation, focusing on cutting-edge research in AI, robotics, sensors, and communications in agriculture. Each QUAD nation contributes up to US$ 2.5 million annually to support joint research proposals.
- AI-ENGAGE fosters collaboration between researchers from Australia, India, Japan, and the USA to advance precision agriculture using AI, sensors, and robotics for sustainable food production.
- The initiative is implemented by ICAR (India), U.S. National Science Foundation (NSF), Australia's

A four-member delegation from the Government of the Republic of Trinidad and Tobago led by Dr. John C. Alleyne, Special Advisor (Agriculture) to the Prime Minister visited ICAR on 19 September 2024 and discussed with Dr Himanshu Pathak, Secretary (DARE) & DG (ICAR) and other ICAR officials on the cooperation in agriculture research and capacity building.

CSIRO, and Japan Science and Technology Agency (JST). In India, ICAR, in collaboration with the Department of Agriculture and Farmers Welfare and the Ministry of Electronics and Information Technology, implements AI-ENGAGE, with coordination by the Principal Scientific Advisor to the Government of India.

- A Quadripartite Memorandum of Cooperation for implementation of AI-ENGAGE initiative under QUAD was signed on 5th August, 2024 by ICAR, NASF, JST and CSIRO.

International Delegation Visits

IR division coordinated 125 foreign delegation to the ICAR Headquarters and 113 ICAR Research Institutes across India in 2024 adhering to the Government of India protocols. These included leaders, diplomats, advisors, vice-chancellors, and scientific experts from nations like European Union, the United States of America, the United Kingdom, South Africa, Brazil, Argentina, Trinidad and Tobago, Mexico, Australia, New Zealand, Italy, France, Malaysia, Fiji, Nepal, and others. These visits foster international collaboration, facilitate knowledge and technology exchange, and address shared agricultural challenges. They support joint research, highlight India's agricultural advancements, and enhance trade, market access, capacity building, diplomatic ties, and rural development.

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21. Training and Capacity Building

As part of the Government of India's Mission Karmayogi initiative, 294 employees from DARE and ICAR were onboarded onto the i-GOT Karmayogi platform to enhance their skills across various domains and contribute to the development of a skilled and professional workforce. The Capacity Building Unit (CBU) of DARE/ICAR implemented the Annual Capacity Building Plan (ACBP) for 2023-24, coordinating training for 2,347 employees. This included 1,267 scientists, 485 technical staff, 504 administrative/finance staff, and 91 skilled support staff (SSS). Compared to 2013-14, there was a notable increase in training, with a 31.1% rise for technical staff and a 127.5% increase for SSS. Highest number of employees trained were under Crop Science Division (595) followed by the NRM Division (425). Additionally, 223 ICAR scientists received specialized training in pedagogical skills, and 245 employees were nominated for external training programmes by other organizations. A total of 354 training programmes were organized by ICAR across categories, with the Agriculture Education Division organizing the most for scientists (108). Overall, 16.8% of employees participated in training programmes, reflecting a 4.1% improvement in capacity building compared to 2013-14. This indicates a successful effort in strengthening employee competencies, coordinated by the HRM Unit of ICAR.

Online onboarding of DARE/ICAR employees on the Mission Karmayogi Platform

As part of new initiatives by the Government of India (GoI), user accounts for DARE and ICAR employees were created on the Digital Learning Framework, i-GOT Karmayogi (Integrated Government Online Training Karmayogi Platform), under Mission Karmayogi, Department of Personnel and Training, GoI, New Delhi. This initiative is designed to enhance functional, behavioral, and domain-specific competencies, while fostering a professional, well-trained, and forward-thinking workforce at DARE/ICAR, to meet the aspirations of Mission Karmayogi. As part of these ongoing reforms in public human resource management and governance, 294 employees of DARE/ICAR HQs were onboarded onto the i-GOT Karmayogi platform.

Formulation and Implementation of the Annual Capacity Building Plan (ACBP) of DARE/ICAR

The Capacity Building Unit (CBU) of DARE/ICAR developed and implemented the Annual Capacity Building Plan (ACBP) for 2023-24. This initiative aimed to train and enhance the capabilities of all categories of DARE/ICAR employees, in line with the vision of Mission Karmayogi and as a key component of the CBC's mandate. The Human Resource Management (HRM) Unit of Agricultural Education Division, ICAR, coordinated the training and capacity building initiatives.

Training and Capacity Building of ICAR Employees

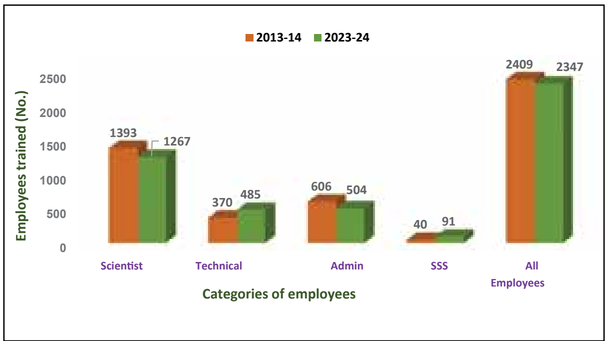
During the reporting period, a total of 2,347 employees participated in various training and capacity-building programmes. This included 1,267 scientists, 485 technical staff, 504 administrative and finance staff, and 91 skilled support staff (SSS). Compared to 2013-14, there was a significant improvement in the number of employees trained, with a 31.1% increase in technical staff and a 127.5% increase in SSS during 2023-24. The Crop Science Division deputed the highest number of participants for capacity-building programmes, consisting of scientists (318), technical staff (140), and SSS (37), while the ICAR Headquarters deputed the highest number of administrative and finance staff (137). Overall, the largest group of employees trained came from the Crop Science Division (595), followed by the NRM Division (425), out of the 2,347 employees trained across the ICAR system.

SMD-wise employees trained during 2023-24

SMDs/HQs	No. of employees trained				
	Scientists	Technical	Administration and Finance	SSS	Total
Crop Science	318 (21.2%)	140 (12.9%)	100 (14.8%)	37 (4.3%)	595 (14.4%)
Horticultural Science	227 (32.8%)	77 (13.5%)	70 (20.8%)	34 (9.3%)	408 (20.8%)

SMDs/HQs	No. of employees trained				
	Scientists	Technical	Administration and Finance	SSS	Total
Natural Management	241 (33.9%)	130 (17.5%)	54 (16.5%)	0 (0%)	425 (20.1%)
Agricultural Education	72 (48.3%)	15 (24.6%)	10 (11.6%)	9 (16.4%)	106 (30.2%)
Agricultural Engineering	46 (24.3%)	28 (14.8%)	24 (24.0%)	7 (12.5%)	105 (19.7%)
Animal Science	173 (25.2%)	49 (7.8%)	55 (13.6%)	2 (0.2%)	279 (10.6%)
Fisheries Science	132 (24.5%)	28 (6.7%)	41 (15.9%)	2 (0.8%)	203 (13.8%)
Agricultural Extension	10 (22.2%)	7 (6.3%)	13 (28.9%)	0 (0%)	30 (14.6%)
ICAR HQs	48 (60.0%)	11 (23.4%)	137 (31.0%)	0 (0%)	196 (32.2%)
Total	1,267 (27.6%)	485 (12.6%)	504 (18.8%)	91 (3.2%)	2,347 (16.8%)

Figures in parenthesis indicate percentage



Comparison of trainings imparted to ICAR staff during 2013-14 and 2023-24.

Nomination of scientists of ICAR-IARI Hubs in specialized training programmes: As a new initiative, ICAR nominated 271 Scientists working in ICAR-IARI hubs in training programmes on 'Enhancing Pedagogical Competencies for Agricultural Education' organized by NAAS, New Delhi in five batches during 2023-24. Out of 271 nominated Scientists, 223 Scientists attended the said training programmes.

Batch	Duration	Nominated (No.)	Attended (No.)
I	31 July-05 August 2023	60	45
II	25-30 September 2023	50	40
III	20-24 November 2023	50	48
IV	29 January to 02 February 2024	62	50
V	04-08 March 2024	49	40
Total		271	223

Nomination of employees in various training programmes: The ICAR also nominated 245 employees of various categories in training and capacity building programmes organized by other agencies, namely, ISTM, New Delhi; AJNIFM, Faridabad; PRIDE, New Delhi; V.V. Giri National Labour Institute, Noida; IIPA, New Delhi; NAARM, Hyderabad, etc., out of which 121 attended the training programmes.

Trainings Organized by ICAR

A total of 354 training programmes were organized for scientists (261), technical staff (59), administrative and finance staff (27) and SSS (7) during 2023-24. The Agriculture Education Division organized the most training programmes for scientists (108); the Crop Science Division for technical staff (18), ICAR HQs for administrative staff (6); and Crop and Horticultural Science Divisions for SSS (2 each). Overall, maximum number of training programmes for all employees were organized by Agriculture Education Division (117) and was followed by Crop Science Division (63).

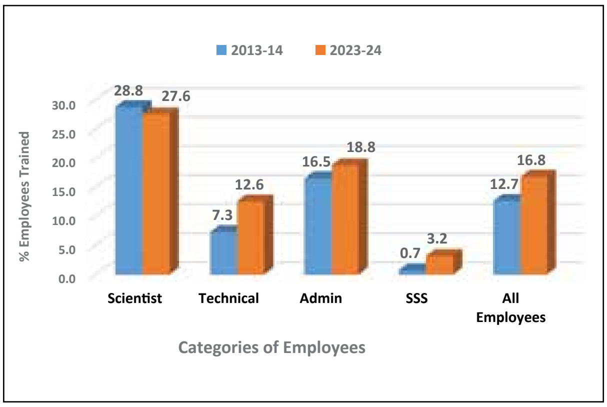
Some selected training programmes coordinated by the HRM Unit, Agricultural Education Division, ICAR, are presented in table given here.

Number of trainings organized by various SMDs/ICAR HQs during 2023-24

SMDs/HQs	Scientists (No.)	Technical Staff (No.)	Administrative and Financial Staff (No.)	SSS (No.)	All employees (No.)
Crop Science	41	18	2	2	63
Horticultural Science	15	7	3	2	27
NRM	20	3	5	1	29
Agricultural Education	108	4	5	0	117
Agricultural Engineering	12	7	1	1	21
Animal Science	21	10	1	1	33
Fisheries Science	31	8	2	0	41
Agricultural Extension	9	1	2	0	12
ICAR HQs	4	1	6	0	11
Total	261	59	27	7	354

Training programmes organized by various institutes in coordination with HRM Unit, ICAR HQs during 2023-24.

Training Programme	Organized by	Beneficiaries
Recent Advances in Data Analysis and Application	ICAR-IASRI, New Delhi	Scientific and technical staff (34)
Domestic component of the Executive Development Programme (EDP) on Leadership Development for newly recruited Research Managers	ICAR-NAARM, Hyderabad	66 RMPs (including ADGs, Directors, and Joint Directors), in three batches
Digital Competency: New Tools and Software for Efficient Computer Applications (online)	ICAR-IASRI, New Delhi	Scientists of ICAR (28)
E-Governance Tools and Applications at ICAR (online)	ICAR-IASRI, New Delhi	Scientific and technical staff of ICAR (30)
Management and Utilization of Plant Genetic Resources (online)	ICAR-NBPGR, New Delhi,	Scientists (65)
Layout and Maintenance of Field Experiments and Recording Observations on a Real-Time Basis	ICAR-IARI, New Delhi	Technical staff of ICAR/non-ICAR Institutes (24)
Good Agricultural Practices for Enhancing Resource-Use Efficiency and Farm Productivity	ICAR-IARI, New Delhi	Technical staff of ICAR/non-ICAR Institutes (25)



Comparison of employees (%) undergone trainings with the creation of HRM Unit during 2013-14 and 2023-24.

Improvement in Capacity Building of ICAR Employees with the Creation of HRM Unit

In 2023-24, employees from different categories received training based on their specific needs, with 27.6% of scientists, 12.6% of technical staff, 18.8% of administrative staff (including finance), and 3.2% of skilled support staff (SSS) participating in various programs. Overall, 16.8% of employees across all categories were provided with capacity-building opportunities. Compared to 2013-14, there was a 5.3% increase in training opportunities for technical staff, a 2.3% increase for administrative and finance staff, and a 2.5% increase for SSS. This resulted in an overall improvement of 4.1% in the capacity building of employees across all categories.

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22. Gender Budgeting

Gender budgeting is an inclusive approach that integrates gender considerations into budget planning to address disparities in health, education, employment, and agriculture. India has aligned its gender-responsive budgeting (GRB) efforts with international commitments such as the Sustainable Development Goals (SDGs). The Gender Budget Cell within DARE-ICAR spearheads these initiatives, focusing on addressing gender imbalances in agriculture through policies and equitable resource distribution. ICAR-CIWA, in collaboration with KVKs and state agricultural universities, advances gender-focused research and interventions in agriculture. Key activities include gender sensitization, capacity building, and technology-driven drudgery reduction. Innovations such as the pedal-operated coconut dehusker and rotary goat feeding system enhance productivity and alleviate women's physical burdens. The institute also promotes digital agriculture by training women farmers in drone technology and implements the Nutri-Smart Villages programme to address malnutrition and improve food security. Climate change exacerbates challenges for women farmers, particularly in vulnerable regions. ICAR-CIWA has developed adaptive strategies, including resilient crop choices and water-saving practices. Tools like the Livestock Farmer's Livelihood Vulnerability Index (LLVI) assess the vulnerability of women livestock farmers, tailoring adaptive measures to mitigate risks. ICAR-CIWA has pioneered entrepreneurship models to empower rural women. The Sustainable She-Preneurship in Mushroom Cultivation Model (2S2M) fosters skill development, resource access, and leadership in mushroom farming. This initiative has created 47 Self-Help Groups (SHGs) and the Bhargabi Women Mushroom Producer Federation, significantly improving women's income and nutrition. Similarly, the Gender-Sensitive Community-based Agripreneurship Model (GCAM) has empowered rural women through training in livestock and fisheries, enabling significant earnings from poultry, goat rearing, and fish product sales.

The AICRP on Women in Agriculture has collected extensive data across 12 states, revealing women's significant involvement in sectors like dairy and horticulture. Despite this, women remain excluded from key decision-making areas. Programmes like the Nutri-Smart Village and Shree Anna Gram have enhanced nutritional security through nutri-gardens and millet cultivation, improving women's dietary intake and agricultural practices. Additionally, drudgery-reducing technologies and Custom Hiring Centres have been established for food processing, benefiting women across multiple states. An assessment of government schemes in the animal husbandry sector highlighted limited gender inclusiveness. Of 373 schemes reviewed, only 29 are exclusively for women, and 92 have special provisions. Programmes such as backyard poultry in Uttar Pradesh and dairy schemes in Manipur benefit women, but challenges like insufficient gender-disaggregated data, inadequate subsidies, and limited training opportunities remain. Climate change impacts on cropping patterns and productivity have led to shifts in livelihood strategies, increased pest incidences, and higher chemical usage in agriculture. These challenges have prompted the adoption of climate-resilient practices and gender-specific adaptations. Overall, gender budgeting and ICAR-CIWA's initiatives have significantly empowered rural women, enhancing their economic independence, livelihood security, and contributions to agricultural sustainability while addressing nutrition and climate resilience challenges. KVKs have assessed 275 technologies for women's empowerment, focusing on health, nutrition, and value-addition. In Karnataka, a women-led SHG transformed pierced silkworm cocoons into profitable products like garlands and bouquets, generating significant income and promoting entrepreneurship. This initiative highlights the potential of value-addition in sericulture, fostering rural self-employment and showcasing innovative uses for agricultural byproducts.

Fundamentals of Gender Budgeting

Gender budgeting is an approach that incorporates a gender perspective into budgetary processes to promote gender equality. It involves analyzing government budgets through a gender lens to ensure that spending, revenue, and resource allocation address gender disparities in sectors such as health, education, and labour. This approach promotes gender equality, enhances economic efficiency, and improves policy outcomes by tackling gender-specific challenges in budgeting. It also supports social justice by ensuring a fair distribution of resources and aligns with international commitments, such as achieving the Sustainable Development Goals on gender equality. By fostering equitable access to services and economic opportunities, gender budgeting helps reduce inequalities in areas like healthcare, education, and employment.

The Gender Budget Cell in DARE-ICAR was established to implement and support Gender Responsive Budgeting (GRB) initiatives. Its objective is to influence and transform the Ministry's policies and programmes to address gender imbalances, promote gender equality, and ensure public resources are allocated and managed accordingly. Additionally, the cell aims to ensure that agricultural policies, programmes, and research initiatives address the unique needs and challenges faced by both men and women in agriculture. This year, the formation of the Gender Budget Cell marks a significant step towards these goals. The ICAR-Central Institute for Women in Agriculture (CIWA), Bhubaneswar, allocates 100% of its budget to conduct various research on gender issues in agriculture and allied fields, while other ICAR schemes do so in various percentages.

Gender Budget Cell of ICAR- Key Activities

- Identifying and addressing gender issues in research and extension.
- Organizing capacity-building programmes on gender sensitization and mainstreaming.
- Providing training on gender budgeting for scientific personnel.
- Advocating for gender-friendly tools for reducing drudgery and enhancing food security.
- Offering amenities like women's hostels, safe transport, security, and gender training to support women farmers.
- The inputs in form of high yielding seeds, small goats, pigs, poultry etc. were also provided to farm women to start their own means of earning livelihood
- Preparation of Gender Budgeting Statement

Empowering Women in Agriculture through Technology Development and Adoption

The ICAR-CIWA is exclusively dedicated to research on women in agriculture. Through the AICRP on Women in Agriculture, ICAR-CIWA collaborates with 13 State Agricultural Universities across 12 Indian states to address gender issues in agriculture and allied sectors through various research initiatives. The institute also hosts an AICRP center focused on Ergonomics and Safety in Agriculture (ESA). Some key achievements during this period are enumerated below.

Women-friendly coconut dehusker: ICAR-CIWA developed a Pedal-Operated Women-Friendly Coconut Dehusker, designed based on the anthropometric and strength dimensions, such as hand reach, sitting leg reach, and leg push force, of Indian male and female agricultural workers. This innovation enables workers to dehusk coconuts while seated for extended periods, utilizing leg push force instead of hand pull force. The design minimizes drudgery and occupational health risks, saving time, labour, and energy. It is particularly effective for women working in small-scale coconut and coir industries. ICAR-CIWA has filed a design registration for the "Pedal-Operated Coconut Dehusker" (Design Application No: 435148-001).

Rotary goat feeding system: ICAR-CIWA has designed and developed the 'Rotary Goat Feeding System', a gender-friendly technology aimed at simplifying the feeding process for women farmers. This system features a revolving structure equipped with separate compartments for feed and fodder, as well as a pulley for easy transportation, supported by a lock-and-key mechanism. Women can stand in one place and efficiently feed 15–20 goats by placing feed in the outer section and fodder in the inner chamber, rotating the feeder as needed. The system significantly reduces the physiological workload for women farmers compared to the traditional horizontal rack system. Key findings include lower energy expenditure (8.00 vs. 9.45 kJ/min), reduced total cardiac cost of work (357.77 vs. 466.43 beats), and decreased physiological cost of work (35.78 vs. 46.64 beats/min) ($P<0.05$). The system minimizes time, energy, and the need for prolonged bending, thereby reducing discomfort, pain, musculoskeletal disorders, and occupational health hazards. ICAR-CIWA has filed a design registration for the Rotary Goat Feeding System (Design Application No: 422770-001). The technology, branded as TechCIWA-Rotary Goat Feeding System, has been commercialized with Maheera FPC Ltd., Balipatana, Khordha, and Manikstu Agro Pvt. Ltd., Bhawanipatana, Kalahandi, Odisha.

Sensitizing women farmers on Drone Technology: Digital agriculture is revolutionizing the farming landscape by increasing agricultural productivity and sustainability with easy to operable technologies that provides unique opportunities to empower women farmers. Around 53 demonstrations were carried out in 29 villages of 6 districts in Odisha covering 2,500 farmwomen for creating awareness about application of digital technologies in agriculture.

Development of Nutri Smart Villages for food security and dietary diversity for combating malnutrition: Nutrition Smart Village programme was undertaken at ICAR-CIWA with participation of 300 farmwomen from 10 villages covering 7 blocks in four districts (Puri, Khorda, Cuttack and Jagatsingpur) of Odisha. Impact assessment of suitable technological interventions on nutri-rich food production showed an increase in establishment of nutrition gardens (224%), aquaculture ponds (156%), backyard poultry units (183%) and mushroom production (156%) in the adopted villages. The overall improvement in behavioural attributes like Knowledge, Attitude and Practice (KAP) by 44.35%. There was enhanced consumption of nutri-rich food such as fruits and vegetables (75.39%), fish (15.36%), mushroom (146%), egg (674.59%) and poultry meat (255.55%). An increase in mean B:C ratio in nutri-smart agri units like nutri-gardens (228%), mushroom cultivation (150%), homestead aquaculture (23.13%) and backyard poultry (93.62%) with overall mean improvement of 123.69%.

Climate Change Adaptations for Women

Climate change and adaptation strategies for farm women: A study on the impact of climate change on farm women's perceptions and adoption of climate-resilient technologies across different topographies (lowland, midland, upland) in three blocks of Keonjhar district—an area vulnerable to climatic threats—highlighted key strategies to mitigate the effects of climate change. These strategies include the adoption of climate-resilient crops, adjusting sowing dates, and utilizing technologies such as conservation agriculture and zero-tillage (mean score: 1.81). Other important strategies include natural farming, crop insurance (PMFBY), and intensified *rabi* cropping during *kharif* failures (score: 1.80). Water-saving practices, intercropping, reduced plant populations in stress seasons, and labor-saving tools follow with mean scores ranging from 1.73 to 1.79. Long-term adaptation involves farm diversification and pursuing non-agricultural income sources. Additionally, community preparedness, along with drought prediction and monitoring, plays a crucial role in ensuring timely and effective mitigation against climate impacts. ICAR-CIWA developed the Women-Friendly Multipurpose Integrated Vertical Nutri-Farming System (IVNFS), which was demonstrated in 21 households across four villages in three districts (Puri, Khordha, and Jagatsinghpur) of Odisha. On average, each system increased the annual availability of vegetables (71.17 kg), mushrooms (30.11 kg), meat (33.56 kg), and eggs (1,677 numbers) per household. This resulted in annual savings of ₹12,000 per household from a single unit.

Assessing the vulnerability of women livestock farmers to climate change: Livestock can serve as a potential buffer against climate shocks, yet it can also become a burden, amplifying vulnerability during disasters. The Livestock Farmer's Livelihood Vulnerability Index (LLVI) is an adaptation of the existing Livelihood Vulnerability Index (LVI), specifically developed for livestock farmers. The LLVI builds on the original seven components of the LVI, which assess vulnerability through the dimensions of exposure, sensitivity, and adaptive capacity. Additionally, the LLVI introduces a new component–animal vulnerability–which specifically evaluates how livestock are affected by climate-related risks. The study conducted on 50 women livestock farmers from two villages, Talatamala and Kathakota, in cyclone-prone districts of Puri and Jagatsinghpur in Odisha revealed that, Kathakota being more exposed to climate risks, women in Talatamala had a higher vulnerability score (0.478) compared to those in Kathakota (0.413). The higher vulnerability in Talatamala was attributed to poorer socio-demographic conditions, including larger family sizes, lower educational levels, and weaker social networks, contributed to reduced adaptive capacity. Additionally, limited control over resources and poor health increased their sensitivity to climate impacts.

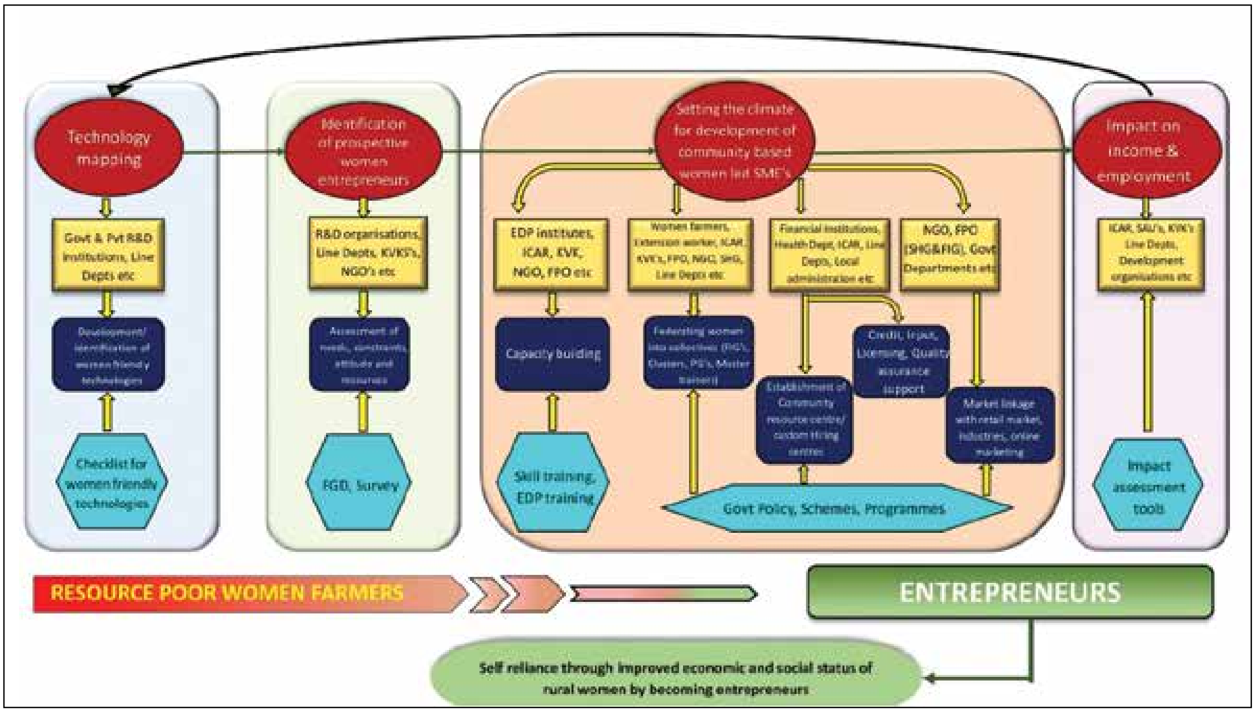
The Livestock Livelihood Vulnerability Index (LLVI) was assessed in Rajasthan (drought), Bihar (flood), Andhra Pradesh (cyclone), Odisha (flood and cyclone) exposed to natural disasters through household survey of 100 women farmers in each state. Data were aggregated using a Livelihood Vulnerability Index, which has 3 major contributors (Exposure, Adaptive Capacity and Sensitivity). The LLVI score was highest in study area of Supaul, Bihar (0.538) and lowest in Jagatsinghpur, Odisha (0.426). High vulnerability of Bihar is due to high exposure to natural disaster along with high sensitivity and poor adaptive capacity of the households.

Women Agri-preneurship

Sustainable She-Preneurship in Mushroom Cultivation Model (2S2M): The Sustainable She-Preneurship in Mushroom Cultivation Model (2S2M) was developed to empower rural women by promoting mushroom cultivation as a viable, profitable, and low-labour agricultural venture. This model targeted skill enhancement of farm women in mushroom production, value-addition, enhancing access to productive resources and market opportunities, leadership development, leisure time utilization and developing sustainable entrepreneurship by promoting community-based groups, viz. SHGs and FPOs.

ICAR-CIWA organized various capacity building programmes on mushroom production, value-addition, record keeping, etc. to empower women. As a result, a total of 47 SHGs were registered under Mahila Krushi Gosthi to avail MSME loan. Additionally, a federation “Bhargabi Women Mushroom Producer Federation” consisting of 631 women members from 47 SHGs under five Panchayats in 17 villages was formulated. A Women FPC CIWANI Women Farmers Producer Company Ltd. at Nimapara, Puri was formed consisting of 1,000 women members covering 100 SHGs, 8 Panchayats and 40 villages in which the model was implemented. The 2S2M had positive impact in villages by improving women’s access to resources (35.32%), average annual income (₹1, 30,100/women), and nutrition by 30.15% over pre-project.

Gender-Sensitive Community-based Agripreneurship Model (GCAM) through Livestock and Fisheries Technologies: The GCAM model illustrates a methodological approach for rural women entrepreneurship development by considering the social, technological, physical and economic constraints of the resource-poor farm women. It clearly depicts the approaches, the actors involved in the implementation, the actions to be carried out and the tools to be used for the actions. It emphasizes on amalgamation of women



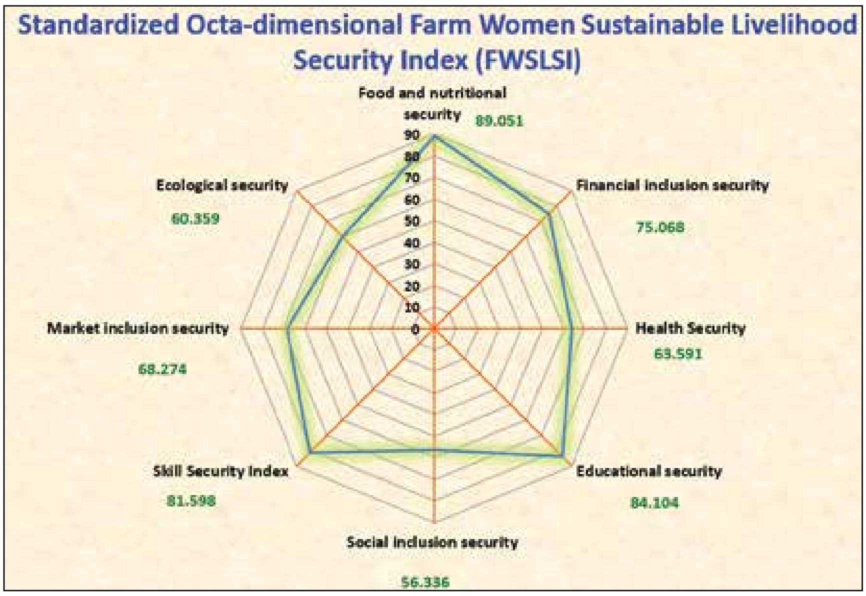
into collectives (Women-SHGs, FIGs, Clusters etc). The model was tested in 6 districts of Odisha state, i.e. Ganjam, Jagatsinghpur, Puri, Khordha, Cuttack and Jajpur. Women led enterprise development on value added product development from fish, small scale poultry production and broiler goat rearing was done through needs and constraint analysis, resource mapping, technology identification, capacity building, creating pool of master trainers, formation of women collectives, establishment of community resources, credit and market linkage. The rural women are earning a gross income of ₹25,000/month through adoption of small scale poultry production of 200 Vanraja birds. A goat rearing unit of broiler black Bengal goats (20+1 goats) is giving a profit of ₹ 15000/ month. The production of value added fish products is helping Women SHG, to earn ₹50,000/ month. It is a model of practice which could act as a decision making and service delivery framework to guide the implementing agencies for fostering rural women entrepreneurship.

AICRP on Women in Agriculture

Development of repository of database to analyze the dynamics and role of women in agriculture: The data collected from 6,000 households across 12 states, viz. Tamil Nadu, Maharashtra, Punjab, Uttarakhand, Himachal Pradesh, Meghalaya, Haryana, Telangana, Rajasthan, Assam, Karnataka and Bihar revealed that women dominate the crop sector in Tamil Nadu, Haryana, and Himachal Pradesh, with minimal engagement in Punjab, Uttarakhand, Maharashtra, and Rajasthan. In horticulture, women in Rajasthan led in participation (63.58%) and decision-making (63.66%), while in Telangana, participation was notably high in 8–18 activities (73–99%). Women's engagement was more in horticulture, followed by floriculture and sericulture in Himachal Pradesh and Meghalaya. In the dairy sector, Tamil Nadu showed the highest female involvement (74.5%), with 100% participation in dung cake making in Uttarakhand and milk processing in Haryana (88%) followed by Telangana (84%). Women also played a critical role in poultry, achieving 100% participation in Meghalaya. However, women's decision-making remained limited in marketing and finance sector.

Standardization of Farm Women Sustainable Livelihood Security Index (FWSLSI): A structured questionnaire was prepared and data collected from 8,690 households. The Standardized Octa-dimensional Farm Women Sustainable Livelihood Security Index (FWSLSI) was developed for all 13 AICRP centres to compute the Livelihood Security Index. To develop the index selection of dimensions and indicators was done through an extensive review of literature and expert input. Relevancy Weightage of 98 indicators was computed and those indicators whose cut-off was ≥0.70 were selected thus, finally having 84 indicators. The Food and Nutritional Security Index (FNS) had maximum weightage followed by the Educational Security (EduS) 84.104; Skill Security Index (SkillS) 81.598; Financial Security Index (FinS) 75.068; the Market Inclusion Security (MIS) 68.274; Health Security (HS) 63.591; the Ecological Security Index (EcoS) 60.359 and Social Inclusion Security Index (SIS) with weightage of 56.336.

Impact of Interventions in Nutri-Smart Village Programme: The Nutri-Smart Village (NSV) Programme was initiated by ICAR-CIWA along with its 13 AICRP on WIA Centres to strengthen the POSHAN Abhiyan with adoption of 75 villages in 13 states and 23 districts of India. This programme achieved a good success during the year with a total of 2,500 nutri-gardens and 90 nutri-farming, established as per the needs of the farming community, available resources and market preferences for promoting gender friendly nutritional enhancement, livelihood upliftment and entrepreneurship development. The study on effect of nutri-gardens, nutri-farms, trainings, workshops, exhibitions and awareness programmes organized under NSV Programme on nutrient intake by farm women was undertaken by the AICRP-WiA Centres. The results indicated that after the intervention there was a significant increase in the percent adequacy of all the nutrients, however, a significant increase was found in protein (80.32–90.28%), vitamin C (65.92–86.12%), iron (65.44–85.0%) and zinc (61.51–74.77%) intake, respectively. The percent adequacy of GLVs, other vegetables, roots and tubers for consumption were increased to 85.50, 65.53 and 77.53%, respectively. The nutrition literacy was enhanced by awareness and sensitization programmes on different aspects of nutrition, viz. nutritional importance of millets,



pulses, leafy vegetables, fruits etc., which was found effective as before intervention 82% of sample were found having low KAP levels and after conducting nutrition education programmes 63% of sample have moderately improved KAP levels.

Wealth from pierced silkworm cocoons: A new avenue for empowering women

In Chikkaballapura, Karnataka, sericulture plays a vital role in the local economy, involving mulberry cultivation, silkworm rearing, and silk production. A significant byproduct of this process is pierced cocoons, which are unsuitable for silk reeling and typically sold at low prices. Recognizing the potential for value-addition, KVK, Chikkaballapura initiated entrepreneurship development programmes in 2021-22 and 2022-23 to promote the use of pierced cocoons. This led to the formation of a Self-Help Group (SHG), 'Nandana Karakushala Vasthugala Thayarika Hagu Maratagarara Sangha,' consisting mainly of women farmers. With KVK's technical guidance, the SHG began crafting products such as garlands, VIP garlands, and bouquets from pierced cocoons. For example, each garland took 4 h to make, costing ₹225, and was sold for ₹600. VIP garlands took 8 h to prepare, with a cost of ₹450, and were sold for ₹1,200. Bouquets were quicker to make, requiring 1 h and costing ₹80, with a selling price of ₹200. In a month, the SHG produced 30 garlands, 12 VIP garlands, and 96 bouquets, incurring total costs of ₹19,830 and generating ₹51,600 in sales, resulting in a net income of ₹31,770. Through KVK's support, the SHG showcased their products at agricultural fairs and exhibitions, expanding their market reach. This initiative has empowered rural women, created self-employment opportunities and showcased the potential of pierced cocoons as a viable small-scale industry with significant growth potential.

Value-addition to pierced silkworm cocoons to beautiful garlands and bouquets by Women SHG

Shree Anna Gram Programme: ICAR-CIWA launched the 'Shree Anna Gram' Programme - A New Vista for Nutritional Security and Women Empowerment' across 30 villages in Odisha and 12 other states involving 13 AICRP centres to promote millets as a means to nutritional and livelihood enhancement. The programme focused on the distribution of millet seeds, including foxtail millet, little millet, brown top millet, sorghum, and barnyard millet and conducting field demonstrations in targeted villages involving proper cultivation techniques such as land preparation, sowing, watering, pest management and harvesting. As a result, millet cultivation increased by 142.35 ha (from 488.28 ha to 630.63 ha) across the 12 states involved in the programme. Under AICRP on Women in Agriculture, two technologies, i.e. finger guards (Nakhalya) and digging tool developed by VNMKV, Parbhani and Punjab Agricultural University were tested and validated to reduce drudgery in farm women. Integrated Pest Management, Integrated Nutrient Management, mushroom cultivation, bee keeping, dairy, livestock, vermicomposting, fodder cafeteria drudgery reducing technologies etc. were identified as some of the areas where women needed technological backstopping. The technology "Revolving milking stool and stand" has been commercialized with Singhvi Sales Corporation, Udaipur, Rajasthan. Additionally, five Custom Hiring Centres were established to empower farm women through primary food processing and value-additions, fish processing and value-addition, farm machine and primary processing of agri produce under SCSP, NICRA CGC funded project and OPIICRA project in Odisha. Furthermore under AICRP on Women in Agriculture, one Custom Hiring Centre for livelihood security was established at Soundarajapuram, Theni, Madurai, Tamil Nadu and another for for Multi commodity Level Food Processing and Value-addition at Shiggaon Taluk, Haveri district of Karnataka.

Analysis of Schemes and Policy Issues

Assessing government schemes in animal husbandry sector for women inclusiveness: Government programmes and schemes in India's animal husbandry sector were evaluated through a gender lens, revealing a lack of specific schemes and funds dedicated to women's empowerment. However, some schemes were identified as women-specific, benefiting poor women, including widows and destitutes. These include poultry and dairy programmes in Manipur, breed multiplication in Mizoram, backyard poultry in Uttar Pradesh, centrally sponsored schemes in Tripura, poultry missions and feed and fodder development in Sikkim, the National Livestock Mission in Nagaland, and milch animal and heifer units in Andhra Pradesh. The evaluation of these schemes highlighted the need for subsidies and programmes that integrate women in the dairy, goatery, and poultry sectors to achieve the goal of women's empowerment. A review of 373 schemes implemented by the GoI and 29 states revealed that 92 schemes have special provisions for women farmers, 29 are exclusively for women, and 108 have scope for involving women farmers. Despite this, significant challenges remain, especially in obtaining gender-disaggregated data for various schemes and making it publicly available. Strengthening institutional mechanisms through targeted interventions, proper follow-up, skill-oriented training, and advocacy is crucial for influencing macro-policies, legislation, and programmes that will empower women farmers.

Perception of farming community about climate change and multisite testing of drudgery reducing tools: Climate change is significantly impacting cropping patterns and productivity in Himachal Pradesh, Maharashtra, and Uttarakhand, influencing temperature and rainfall throughout the growing season. In response to these changes, the burning of paddy straw and wheat straw has notably altered temperature and rainfall patterns. In Haryana, Punjab, and Telangana, a majority of respondents reported that climate change has led to an increase in crop diseases, pests, and insects. The use of chemicals in agriculture was found to be highest in Telangana (91.7%), followed by Punjab (85.83%) and Haryana (81.66%). This trend includes the introduction of new activities by both men (41.67%) and women (50%), along with a shift in activities between genders and changes in livelihood strategies. The majority of respondents (83.33%) indicated that these shifts have resulted in changes to agricultural practices, adoption of climate-resilient activities, migration, and new job opportunities.

Women empowerment through KVKs: Technology assessment for women empowerment was undertaken by the 721 KVKs wherein 275 technologies pertaining to farm women were assessed through 1,855 trials at 900 locations. Health and nutrition (111 technologies, 825 trials at 484 locations); and value-addition (96 technologies assessed through 492 trials at 278 locations) were the major thematic areas of technologies assessed.

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Promotion of Hindi as Official Language

ICAR ensured compliance with the Official Language Act, 1963, and related directives issued by the Central Government and the Department of Official Language to promote the use of Hindi in official work. Several initiatives were implemented to encourage the progressive use of Hindi across ICAR and its institutes. Programmes for farmers and the public were organized in Hindi and regional languages, and materials on Agricultural Science, Animal and Fisheries Sciences, and Horticultural Sciences were regularly published in these languages. The monthly Hindi magazine Kheti and the in-house publication Rajbhasha Aalok were consistently released, featuring scientific topics, government schemes, and updates on ICAR's activities. Four Official Language Implementation Committee (OLIC) meetings were held at ICAR Headquarters, with similar committees operating regularly at its institutes. Quarterly progress reports were submitted to the Regional Implementation Office, and feedback was provided to enhance policy implementation. ICAR also participated in Town Official Language Implementation Committee (TOLIC) meetings and conducted Hindi workshops in every quarter. Events like Hindi Pakhwara were organized, with competitions and messages promoting Hindi use. Cash awards were presented to employees excelling in Hindi usage. Inspections, including by the Parliamentary Committee on Official Language, ensured compliance, and bilingual preparation of parliamentary documents was maintained.

During the reporting period, ICAR has ensured compliance with the provisions of the Official Language Act, 1963, and the associated Official Language Rules, resolutions, general orders, notifications, administrative reports, and press communiqués issued by the Central Government, its ministries, departments, offices, or entities owned or controlled by the Central Government. Additionally, various directives and instructions issued by the Department of Official Language regarding the progressive use of Hindi for official purposes have been implemented in the ICAR and its institutes.

Progressive use of Hindi

The institutions of the Council organized several programmes in Hindi and regional languages to benefit the public and farmers. Activities, including agriculture extension services by KVKs in Hindi-speaking regions, were conducted in Hindi. The Council and its institutes regularly published materials on diverse topics, such as Agricultural Science, Animal and Fisheries Sciences, and Horticultural Sciences, in Hindi and regional languages. To disseminate agricultural technologies and enhance their reach, the monthly Hindi magazine *Kheti* was published consistently. Additionally, the in-house Hindi magazine of the ICAR Headquarters, *Rajbhasha Aalok*, was also published regularly. This magazine featured articles on scientific topics, government schemes written in simple Hindi, and reports on various initiatives and programmes organized by the Council and its institutes.

During the reporting period, four meetings of the Official Language Implementation Committee (OLIC) were held. Most ICAR institutes and centers have established their own OLICs, which also convene meetings regularly. Quarterly progress reports from the ICAR Headquarters are submitted online to the Regional Implementation Office of the Department of Official Language, Government of India, located in Delhi. The progress reports received from various institutes

are reviewed, and feedback is provided to enhance the effective implementation of the Official Language Policy. Additionally, ICAR actively participates in the meetings of the Town Official Language Implementation Committee (TOLIC). Four Hindi workshops were organized during this period.

As in previous years, Rajbhasha Week, Fortnight, or Month was organized at the Council's Headquarters and its institutes. At the Headquarters, various Rajbhasha competitions were held during Hindi Pakhwara, which commenced on September 14, 2024. On this occasion, inspiring messages from the Hon'ble Union Minister for Agriculture and Farmers Welfare were shared. The Director General of ICAR also issued an appeal, encouraging all officers and employees to carry out their official work predominantly in Hindi.

Under the Cash Award Scheme of Official Language being implemented at the ICAR Headquarters, 10 personnel were given cash awards for doing their maximum work in Hindi during 2023-24.

In accordance with the directives of the Department of Official Language, Ministry of Home Affairs, various ICAR institutes were inspected during the reporting period to evaluate their progress in implementing Hindi. Recommendations were provided to address the shortcomings identified during these inspections, including those conducted by the Parliamentary Committee on Official Language. Furthermore, all documents presented in Parliament, including materials related to the Annual Plan, Demand for Grants, Governing Body meetings, and the Parliamentary Committee of the Ministry of Agriculture, as well as the Annual General Body meetings of the ICAR Society, were prepared bilingually in Hindi and English. During these meetings, the Hon'ble Agriculture Minister and other senior officials delivered their addresses in Hindi.

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24. Publications, Social Media and Public Relations

The ICAR-Directorate of Knowledge Management in Agriculture (DKMA) plays a crucial role in enhancing ICAR's visibility by effectively communicating its research and achievements, through media relations, content creation, and various communication channels aimed at diverse audiences such as policymakers, farmers, researchers, and students. ICAR-DKMA regularly publishes 12 periodicals, including research journals like the 'Indian Journal of Agricultural Sciences' (IJAgS), the 'Indian Journal of Animal Sciences' (IJAnS), and the 'Indian Journal of Fisheries Sciences' (IJFS), which have international recognition. During the reporting period, IJAgS, IJAnS, and IJFS received 4,785 submissions, published 532 articles, and had an h-index of 34, 27 and 20, respectively. A total of 18 issues of Hindi periodicals, Kheti (monthly) and Phal Phool (bimonthly), were published, including four special editions of Kheti and four special issues of Phal Phool. In popular periodicals, 120 articles in Indian Farming and 76 articles in Indian Horticulture, were published, with four two special issues, respectively. ICAR-DKMA also published books, including 'Textbook of Apiculture', 'Chemical Quality Assurance', and Dalhani Faslon ki Suraksha. To enhance the accessibility of research, ICAR's e-publications platform hosts over 41,000 articles from 60 journals and popular periodicals. This open-access portal has expanded ICAR's global reach, with analytics tracking user interactions. Moreover, ICAR introduced measures like Digital Object Identifiers (DOIs) and plagiarism-checking software to maintain publication integrity. Revenue from publication sales and advertisements was generated to the tune of ₹ 77 lakhs. ICAR's website and social media platforms saw considerable traffic, with over 5 million page views and significant engagement on Facebook, X, YouTube and Instagram. A notable achievement was the social media campaign for '100 Days of ICAR Achievements' which further boosted the organization's online presence, promoting technological advancements and research. The publicity and public relations efforts of ICAR included five press conferences, 50 press releases, and active participation in exhibitions, contributing to agricultural knowledge dissemination and raising public awareness of new technologies.

The ICAR-Directorate of Knowledge Management in Agriculture (DKMA) plays a pivotal role in elevating ICAR's prominence by effectively communicating its groundbreaking research and notable achievements. The DKMA team is instrumental in fostering robust media relations, developing high-quality content, and utilizing diverse communication channels to engage a broad spectrum of audiences. By strategically sharing ICAR's innovative initiatives, the team ensures that its message reaches key stakeholders, including policymakers, funding organizations, donors, administrators, farmers, scientists, researchers, and students. As part of its initiatives, ICAR-DKMA publishes a variety of materials, including periodicals, books, handbooks, annual reports, newsletters, bulletins, monographs, e-books, media columns, social media content, and advisories. These publications are made available through both open and closed access models, ensuring accessibility for stakeholders in the agricultural domain. The aim to not only highlight ICAR's contributions to agricultural science and innovation but also to disseminate valuable information that inspires collaboration, supports decision-making, and enhances awareness across various sectors.

Knowledge and Information Products

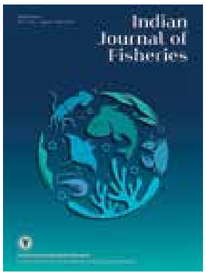
The ICAR-DKMA continued its commitment to publishing 12 regular periodicals, comprising research journals, semi-technical (popular) journals, books, monographs and magazines. A strong focus was placed on creating demand-driven content tailored to meet the specific needs of target stakeholders. Research journals regularly featured review articles by leading experts, while special issues of semi-technical periodicals addressed topical themes. The ICAR-DKMA also provided consultancy and expert support to ICAR constituents for the design, printing, and publication of special materials, further enhancing the organization's communication and outreach efforts.

Research Journals

The Indian Journal of Agricultural Sciences (IJAgS) and *The Indian Journal of Animal Sciences* (IJAnS), are the flagship research journals published by ICAR-DKMA, whilst *The Indian Journal of Fisheries Sciences* (IJFS) is published by ICAR-CMFRI, Cochin, on behalf

Metrics of the three research journals published by ICAR (Nov. 2023-Oct. 2024)

	Issues published	Submissions received	Articles published	Users	Impact factor (2023)	h-index (2023)
IJAgS	12	4,718,	260	27,461	0.4	34
IJAnS	12	1,666	192	14,890	0.4	27
IJFS	04	383	80	11,121	0.4	20



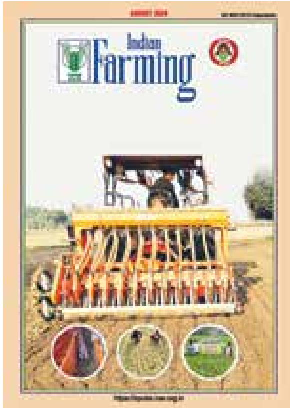
of ICAR. These research journals have international fame and have a wide clientele.

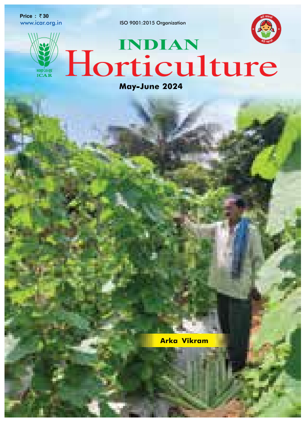
Semi-Technical and Popular Periodicals

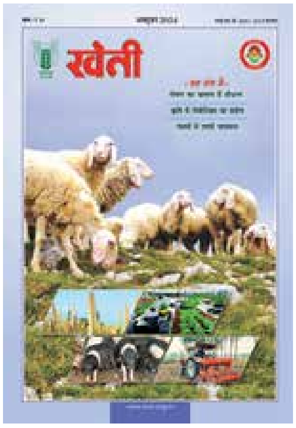
Popular periodicals (in English) such as *Indian Farming* (monthly) and *Indian Horticulture* (bimonthly) were published to engage a wide audience. During the reporting period, *Indian Farming* received 368 submissions, while *Indian Horticulture* received 172. The platforms registered 6,003 users for *Indian Farming* and 3,387 users for *Indian Horticulture.* A total of 120 articles were published in *Indian Farming* and 76 in *Indian Horticulture.* Special issues of *Indian Farming* were released to mark the Golden Jubilee of Krishi Vigyan Kendras International Day of Potato (May 2024) and the Farmers First Programme (October and November 2024). Similarly, *Indian Horticulture* brought out themed editions on *Smart Ornamental Horticulture* (September-October 2024) and *Digital Technologies in Horticulture* (November-December 2024).

The ICAR flagship Hindi periodicals included *Kheti* (monthly) and *Phal Phool* (bimonthly), with a total of 18 issues published during the reporting period. Four special editions of *Kheti* were released, focusing on *Krishi Vigyan Kendra Visheshank, Shrianna Visheshank, Pashudhan Visheshank,* and *Matsya Visheshank.* Likewise, two special issues of *Phal Phool* were dedicated to *Sabzi Visheshank* and *Phal Visheshank.* These special editions were curated to provide comprehensive and up-to-date information on specific topics, benefiting readers with in-depth insights and knowledge.

The in-house publications like *ICAR Reporter* and *ICAR News* are also available on ICAR website for wider global reach. These were viewed in about 140 countries world over.







Books Published

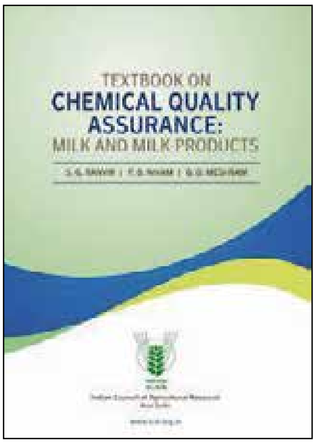
Under the books publication programme, three new titles were published in English, namely, *Textbook of Apiculture, Chemical Quality Assurance: Milk and Milk Products* and *Packaging of Dairy Products*. One book was published in Hindi entitled *Dalhani Faslon ki Suraksha.*

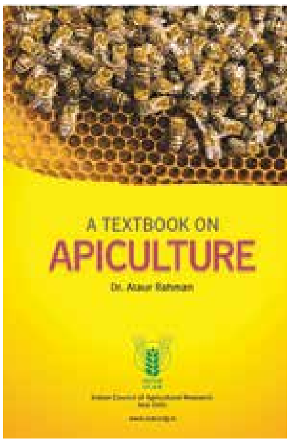
E-Pubs Portal

In 2010, leveraging advancements in ICT, ICAR research journals were made available online through the open-access platform (https://epubs.icar.org.in) for Indian Agricultural Research Journals. Developed under the National Agricultural Innovation Project (NAIP), this platform now hosts 60 journals associated with ICAR-funded scientific societies. It provides a

Metrics of the popular periodicals published by ICAR (Nov. 2023-Oct. 2024)

	Issues published	Submissions received	Articles published	Users registered	Special issues published
Indian Farming	12	368	120	6,003	3
Indian Horticulture	6	172	76	3,387	2
Kheti	12	409	224	561	4
Phal Phool	6	168	102	274	2

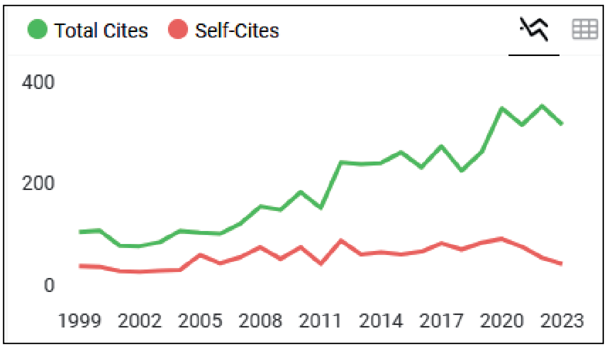


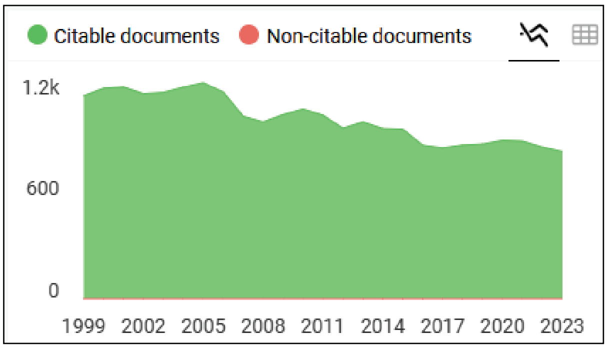


range of features, including an online article processing system, referee system, and access to archives. The portal contains back volumes of research journals, encompassing 317 issues of IJAgS, 328 issues IJAnS and 190 issues of IJFS. Additionally, popular periodicals such as Indian Farming (141 issues) and Indian Horticulture (77 issues) are also hosted. Overall, the platform offers global open-access to approximately 41,000 articles, significantly enhancing the reach and impact of ICAR's scholarly output. This site is connected to Google analytics that provides reports on user flow on this portal.

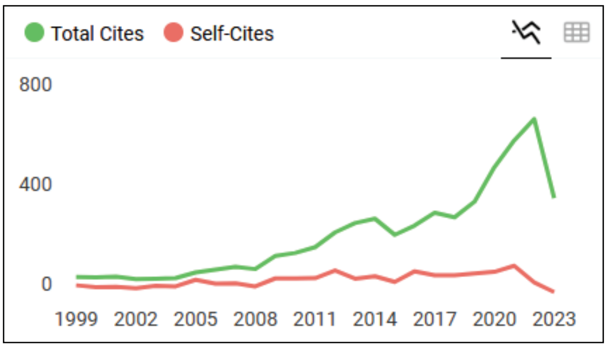
The ICAR-DKMA has implemented several key initiatives to enhance the quality and credibility of its publications. Notably, it has introduced the allotment of Digital Object Identifiers (DOIs) and plagiarism checking for research articles. To facilitate this, subscription has been made to Crossref, USA. DOIs have been assigned to back volumes of the research journals up to 2012. To provide authentic knowledge to readers of the research journals, plagiarism checker software iThenticate was subscribed. For facilitating publication of the books, e-book platform was developed. The international unit system for the content produced is followed for ICAR publications. Additionally, maintenance of Article Certificates and Copyright Deeds for books is also taken care of upholding the highest standards in publishing, ensuring that ICAR's contributions to agricultural knowledge are presented professionally and in line with global best practices.

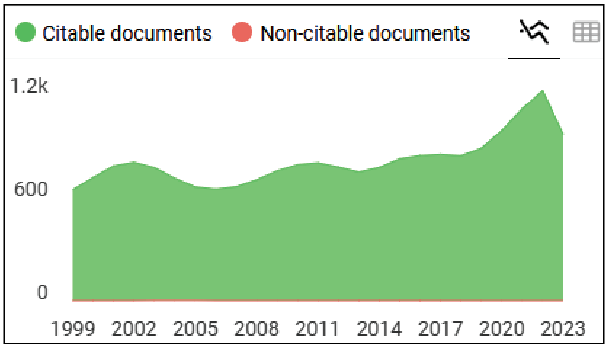
Publication metrics of The Indian Journal of Animal Sciences





Publication metrics of The Indian Journal of Agricultural Sciences

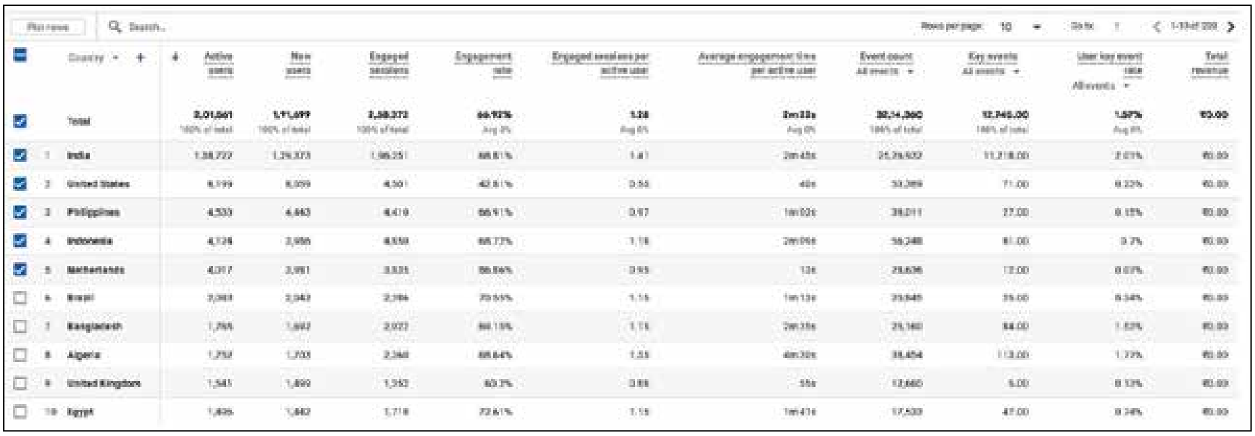




Global visibility of E-Pubs Portal (Google Analytics)

Revenue and Outreach

The ICAR-DKMA plays a crucial role in generating revenue through the sale of ICAR publications by implementing suitable marketing strategies, overseeing sales, promotion and efficient distribution of the Council's key publications and periodicals. A revenue of about ₹ 77 lakhs was earned during the period from November 2023 to October 2024 from the sale of publications and advertisements. For showcasing ICAR publications in various platforms, ICAR-DKMA participated in eight exhibitions in different parts of the country to enhance the visibility and to reach out the target audience.



	Country	Active users	New users	Engaged sessions	Engagement rate	Engaged sessions per active user	Average engagement time per active user	Event count All events	Key events All events	User key event rate All events	Total revenue
	Total	2,01,661 100% of total	1,71,699 100% of total	2,58,372 100% of total	66.92% Avg 0%	1.28 Avg 0%	2m 23s Avg 0%	32,14,360 100% of total	12,745.00 100% of total	1.57% Avg 0%	₹0.00
1	India	1,38,722	1,29,373	1,96,251	68.81%	1.41	2m 45s	25,29,522	11,218.00	2.01%	₹0.00
2	United States	8,199	8,059	4,501	42.81%	0.55	40s	53,289	71.00	0.22%	₹0.00
3	Philippines	4,533	4,443	4,419	66.91%	0.97	1m 02s	39,011	27.00	0.15%	₹0.00
4	Indonesia	4,128	3,956	4,550	68.77%	1.18	2m 09s	56,248	61.00	0.7%	₹0.00
5	Netherlands	4,017	3,981	3,825	86.86%	0.95	13s	28,636	12.00	0.07%	₹0.00
6	Brazil	2,083	2,043	2,386	70.55%	1.15	1m 13s	23,845	35.00	0.34%	₹0.00
7	Bangladesh	1,765	1,692	2,022	88.15%	1.15	2m 35s	25,160	84.00	1.82%	₹0.00
8	Algeria	1,752	1,703	2,360	88.64%	1.35	4m 20s	38,454	113.00	1.77%	₹0.00
9	United Kingdom	1,541	1,499	1,352	60.3%	0.88	55s	12,660	5.00	0.13%	₹0.00
10	Egypt	1,496	1,442	1,718	72.61%	1.15	1m 41s	17,533	47.00	0.34%	₹0.00

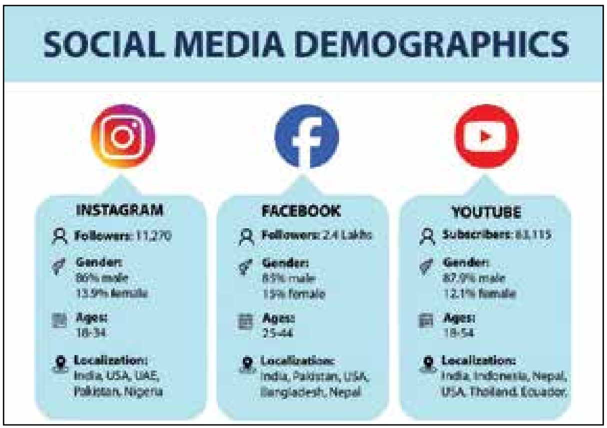
Participation of ICAR-DKMA in exhibitions for showcasing ICAR publications

S.No.	Event	Duration
1	Agri and Horti Expo 2023 (Dilli Haat, Pitampura, New Delhi)	3-5 November 2023
2	Exhibition of ICAR Publications at Maharana Pratap Agricultural University, Udaipur	14-15 March 2024
3	Exhibition of ICAR Publications at Sam Higginbottom University of Agriculture, Technology & Science, Allahabad	25-26 April 2024
4	Exhibition of ICAR Publications at Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli	15-16 May 2024
5	Exhibition of ICAR Publications at Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior	22-23 August 2024
6	Exhibition of ICAR Publications at Agriculture College & Research Institute, Madurai	5-6 September 2024
7	Pantnagar Krishi Mela at GBPUAT, Pantnagar	4-7 October 2024
8	Agrobiodiversity Exhibition, Umiam, Meghalaya	23-25 October 2024

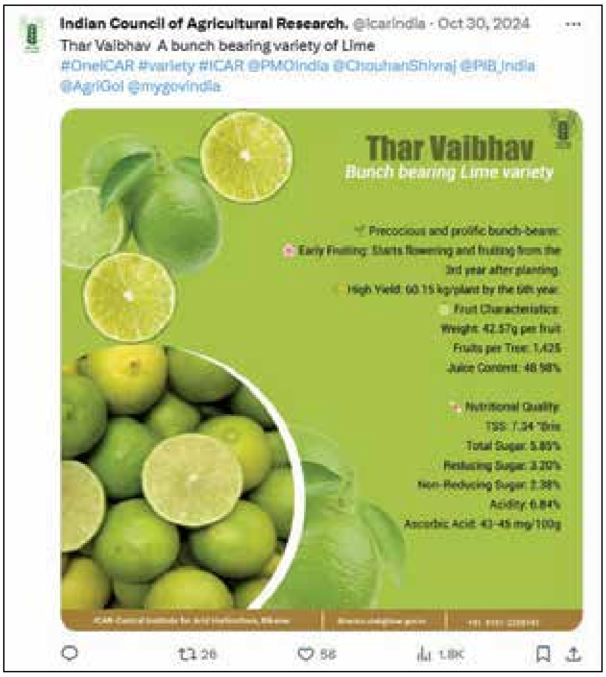
ICAR-DKMA stall at various exhibitions

ICAR Website and Social Media

To facilitate real-time information dissemination, the ICAR website was regularly updated, with a total of 4,809 pages refreshed during the reporting period. The website recorded 5,224,779 page views from over 200 countries, reflecting its global reach. The top five countries accessing the site were India, the United States, the United Kingdom, the United Arab Emirates, and Nepal. The revamped website now includes a Publication Cart, enabling stakeholders to purchase ICAR publications online.



On social media, ICAR maintained an active presence. The ICAR Facebook page averaged three posts per day and amassed 2.4K followers. Similarly, the ICAR Twitter handle posted an average of three tweets daily, gaining over 2,48,458 followers and achieving 3,161.29K impressions. ICAR's YouTube channel, featuring video films, animations, lectures, interviews with dignitaries and eminent scientists, and recordings of national and international events, attracted 83,115 subscribers. A significant milestone was the completion of a 100-day social media campaign from July 1 to October 8, 2024. During this campaign, ICAR's social media platforms (Facebook, X, and Instagram) showcased posts highlighting 100 varieties, 100 technologies, and 100 research papers with NAAS scores above 10, representing contributions from 84 institutes and 69 agricultural universities. This initiative substantially increased the visibility of ICAR's achievements and contributions to agricultural research and innovation.



Publicity, Public Relations, and Media

Recognizing that the adoption of new agricultural technologies relies on stakeholder awareness, the ICAR-DKMA employs strategic communication to engage farmers, scientists, and the public. By collaborating with media personnel, it amplifies ICAR's achievements, promoting a deeper understanding of how research drives agricultural innovation, productivity, and sustainability.

Liaison with print and electronic media: A total of five press conferences were organized during the reporting period, and 50 Press releases were distributed during various events organized by the Council. These were widely covered by national print media as well as electronic media, especially by DD Kisan, All India Radio, PIB, PTI, Univarta, ANI etc. along with numerous national and local newspapers and electronic media.

The policies instituted for the distribution of ICAR video films serve not only to inform various stakeholders but also to promote agricultural advancements, ultimately benefiting the farming community. During the period, several documentary video films were produced for various stakeholders on the activities and achievements of ICAR as a whole and on important issues pertaining to agriculture of immediate concern to farmers. These films are distributed to various ICAR institutes, KVKs, Extension Directorates of SAUs for dissemination of information to farmers.

Participation in various exhibitions and kisan melas: ICAR actively participates in various regional, national, and international exhibitions and Kisan Melas, demonstrating its commitment to advancing agriculture. The ICAR-DKMA plays a key role in these efforts by coordinating with all National Agriculture Research Systems (113 ICAR Institutes and 77 agricultural universities) to provide guidance on exhibition-related matters. Several meetings, mostly held virtually, were organized to discuss ICAR's participation in exhibitions,

improve the quality of documentary films, and ensure comprehensive event coverage. These exhibitions serve as effective platforms to showcase significant advancements in agricultural development, raising public awareness of innovative ideas, new varieties, and emerging technologies. During the reporting period, ICAR participated in around 45 exhibitions, including major events such as the ICAR Foundation Day, Indian Science Congress, India International Trade Fair, and the *Naya Bharat-Viksit Bharat-AtmaNirbhar Bharat* exhibition in Varanasi. In addition to showcasing cutting-edge agricultural technologies, the Council provided valuable guidance to ICAR institutes on exhibition-related matters, promoting collaboration and knowledge dissemination within the agricultural sector.

Single window for advertisement: The ICAR-DKMA provided the insertion of various advertisement facilities to the divisions and sections of the Council throughout the year. Several advertisements for appointments, tenders, etc. were published in newspapers through BOC (DAVP). The advertisements were published in 500 newspapers in Hindi, English and vernacular languages covering all the states of India.

❑

APPENDIX 1

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2023-24 and BE 2024-25 in r/o DARE Secretariat, Contribution, CAUs and NAAS and IAUA are given in Table 1.

Table 1. Budget Estimates and Revised Estimates of DARE

(Rupees in lakh)

Items		Budget Estimates	Revised Estimates	Budget Estimates
		2023-24	2023-24	2024-25
		Unified Budget	Unified Budget	Unified Budget
Major Head	**'3451'**			
090	**Secretariat-Economic Services**	818.00	1493.00	1611.00
091	**Agricultural Scientists' Recruitment Board**	1769.00	2139.00	2787.00
Major Head	**'2415'**			
80	**General**			
80.120	**Assistance to other institutions**			
01	**Grant-in-Aid Central Agricultural University Imphal**			
010031	Grants in Aid General	-	-	-
010035	Grants for creation of Capital Assets	-	-	-
010036	Grants in Aid Salaries	-	-	-
02	**Grant-in-Aid Central Agricultural University Bundelkhand**			
020031	Grants in Aid General	1300.00	1300.00	1300.00
020035	Grants for creation of Capital Assets	9000.00	10000.00	12500.00
020036	Grants in Aid Salaries	1700.00	1700.00	1800.00
03	**Grant-in-Aid Central Agricultural University Bihar**			
030031	Grants in Aid General	1700.00	2000.00	2000.00
030035	Grants for creation of Capital Assets	5367.00	5367.00	5409.00
030036	Grants in Aid Salaries	17744.00	17744.00	18417.00
05	**Grants-in-Aids to National Academy of Agricultural Sciences and Indian Agricultural Universities Association**			
050031	Grants in Aid General	76.00	76.00	31.00
050035	Grants for creation of Capital Assets	-	-	-
050036	Grants in Aid Salaries	-	-	-
06	**Agricultural Scientists' Recruitment Board**			
060031	Grants in Aid General	-	-	-
060035	Grants for creation of Capital Assets	-	-	-
060036	Grants in Aid Salaries	-	-	-
80.798	**International Co-operation (Minor Head)**			
01	**India's Membership Contribution to Commonwealth Agricultural Bureau**			
010032	Contribution	60.00	60.00	65.00
02	**India's Membership Contribution to Consultative Group on International Agricultural Research**			
020032	Contribution	620.00	635.00	635.00

Contd..

(Concluded)

Items		Budget Estimates 2023-24 Unified Budget	Revised Estimates 2023-24 Unified Budget	Budget Estimates 2024-25 Unified Budget
04	**Asia Pacific Association of Agricultural Research Institutions**			
040032	Contribution	10.00	9.70	10.00
05	**N.A.C.A.**			
050032	Contribution	48.00	50.00	50.00
07	**International Seed Testing Association, Zurich, Switzerland**			
070032	Contribution	5.00	5.30	6.00
08	**International Society for Horticulture Science, Belgium**			
080032	Contribution	-	-	-
Major Head	**'2552' North Eastern Areas**			
259	**General (Agri. Res. & Edn. Schemes) (Minor Head)**			
01	**Grants-in-Aid-General to Central Agricultural University, Imphal**			
010031	Grants in Aid General	2900.00	3700.00	3929.00
010035	Grants for creation of Capital Assets	6442.00	6500.00	7200.00
010036	Grants in Aid Salaries	19000.00	18800.00	19800.00
5475	**Capital Outlay on other General Economic Services**			
00.001	Direct and Administration (Minor head)			
01	**Secretariat**			
06	**DARE**			
06.52	Machine and Equipment	4.00	1.00	6.00
06.71	Information Computers Telecommunication Equipment	5.00	10.00	20.00
06.74	Furniture and Fixtures	3.00	1.00	4.00
02	ASRB (Detailed head)			
02.51	Motor Vehicles	-	-	-
02.52	Machinery and Equipment	20.00	24.00	20.00
02.71	Information Computers Telecommunication Equipment	80.00	50.00	220.00
02.72	Building and Structures	800.00	800.00	200.00
02.74	Furniture and Fixtures	119.00	105.00	150.00
02.77	Other Fixed Assets	10.00	5.00	30.00
	Total- ASRB (Sub-Head)	1041.00	996.00	650.00
	TOTAL	**69600.00**	**72575.00**	**78200.00**

Notes on Demands For Grants, 2024-2025

MINISTRY OF AGRICULTURE AND FARMERS WELFARE

DEMAND NO. 2

Department of Agricultural Research and Education

A. The Budget allocations, net of recoveries, are given below: (Rupees in crore)

	Actual 2022-2023			Budget 2023-2024			Revised 2023-2024			Budget 2024-2025		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Gross	8578.15	...	8578.15	9493.59	10.41	9504.00	9866.64	9.96	9876.60	9934.59	6.50	9941.09
Recoveries	-178.43	...	-178.43	...	...	...	...	...	...	...	...	...
Receipts	...	...	...	...	...	...	...	...	...	...	...	...
Net	**8399.72**	**...**	**8399.72**	**9493.59**	**10.41**	**9504.00**	**9866.64**	**9.96**	**9876.60**	**9934.59**	**6.50**	**9941.09**
I Establishment Expenditure of the Centre												
1. Secretariat	40.52	...	40.52	33.30	10.41	43.71	43.92	9.96	53.88	51.64	6.50	58.14
II Central Sector Schemes/ Projects												
2. Agricultural Extension	243.59	...	243.59	327.00	...	327.00	250.00	...	250.00	...	...	...
3. Agricultural Engineering	48.29	...	48.29	65.00	...	65.00	70.09	...	70.09	...	...	...
Management of Natural Resources												
4. Natural Resource Management Institutes including Agro Forestry Research	144.77	...	144.77	240.00	...	240.00	239.98	...	239.98	...	...	...
5. Climate Resilient Agriculture Initiative	40.87	...	40.87	...	...	...	...	...	...	...	...	...
Crop Sciences												
6. Crop Science	525.47	...	525.47	714.41	...	714.41	962.78	...	962.78	...	...	...
7. Horticultural Science	157.49	...	157.49	212.00	...	212.00	217.45	...	217.45	...	...	...
8. National Agricultural Science Fund	35.67	...	35.67	...	...	...	...	...	...	...	...	...
Animal Sciences												
9. Animal Science	223.97	...	223.97	300.00	...	300.00	306.72	...	306.72	...	...	...
10. Fisheries Science	118.88	...	118.88	150.00	...	150.00	150.00	...	150.00	...	...	...
Agricultural Education												
11. Agricultural Universities and Institutions	263.77	...	263.77	322.74	...	322.74	322.74	...	322.74	...	...	...

Contd..

(Continued)

	Actual 2022-2023			Budget 2023-2024			Revised 2023-2024			Budget 2024-2025		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
12. Economic Statistics and Management	24.38	...	24.38	...	...	...	...	...	...	...	...	...
13. National Agricultural Higher Education Project (NAHEP)	166.20	...	166.20	92.26	...	92.26	54.60	...	54.60	...	...	...
14. Strengthening of Krishi Vigyan Kendras (KVKs)	...	...	...	...	...	...	...	...	...	234.89	...	234.89
15. Agricultural Production and Post-Production Mechanization Augmented with Innovative Technologies for Sustainable Agriculture Development	...	...	...	...	...	...	...	...	...	91.24	...	91.24
16. Natural Resource Management	...	...	...	...	...	...	...	...	...	252.16	...	252.16
17. Crop Science for Food and Nutritional Security	...	...	...	...	...	...	...	...	...	930.22	...	930.22
18. Technology based support in improvement and management of horticulture crops towards enhanced and sustainable productivity for nutritional security (Horticultural Science)	...	...	...	...	...	...	...	...	...	257.07	...	257.07
19. Research, Education and Technology Development for Sustainable Livestock Health and Production towards Nutritional Security	...	...	...	...	...	...	...	...	...	415.15	...	415.15
20. Fisheries and Aquaculture for Sustainable Development	...	...	...	...	...	...	...	...	...	200.92	...	200.92
21. Strengthening Agricultural Education, Management & Social Sciences	...	...	...	...	...	...	...	...	...	398.74	...	398.74
Total-Central Sector Schemes/ Projects	**1993.35**	**...**	**1993.35**	**2423.41**	**...**	**2423.41**	**2574.36**	**...**	**2574.36**	**2780.39**	**...**	**2780.39**
III Other Central Sector Expenditure												
Autonomous Bodies												
22. ICAR Headquarters	5934.27	...	5934.27	6384.59	...	6384.59	6576.49	...	6576.49	6378.70	...	6378.70

Contd..

(Continued)

	Actual 2022-2023			Budget 2023-2024			Revised 2023-2024			Budget 2024-2025		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
23. Central Agricultural Universities	608.88	...	608.88	651.53	...	651.53	671.11	...	671.11	723.55	...	723.55
24. National Academy of Agricultural Sciences	1.13	...	1.13	0.76	...	0.76	0.76	...	0.76	0.31	...	0.31
Total-Autonomous Bodies	**6544.28**	**...**	**6544.28**	**7036.88**	**...**	**7036.88**	**7248.36**	**...**	**7248.36**	**7102.56**	**...**	**7102.56**
Others												
25. Actual Recoveries	-178.43	...	-178.43	...	...	...	...	...	...	...	...	...
Grand Total -	**8399.72**	**...**	**8399.72**	**9493.59**	**10.41**	**9504.00**	**9866.64**	**9.96**	**9876.60**	**9934.59**	**6.50**	**9941.09**
Developmental Heads												
Economic Services												
1. Agricultural Research and Education	8366.54	...	8366.54	8941.93	...	8941.93	9281.38	...	9281.38	9303.22	...	9303.22
2. Secretariat-Economic Services	33.18	...	33.18	25.87	...	25.87	36.32	...	36.32	43.98	...	43.98
3. Capital Outlay on Other General Economic Services	...	...	...	...	10.41	10.41	...	9.96	9.96	...	6.50	6.50
Total -Economic Services	**8399.72**	**...**	**8399.72**	**8967.80**	**10.41**	**8978.21**	**9317.70**	**9.96**	**9327.66**	**9347.20**	**6.50**	**9353.70**
Others												
4. North Eastern Areas	...	...	...	525.79	...	525.79	548.94	...	548.94	587.39	...	587.39
Total -Others	**...**	**...**	**...**	**525.79**	**...**	**525.79**	**548.94**	**...**	**548.94**	**587.39**	**...**	**587.39**
Total -	**8399.72**	**...**	**8399.72**	**9493.59**	**10.41**	**9504.00**	**9866.64**	**9.96**	**9876.60**	**9934.59**	**6.50**	**9941.09**
Head of Dev	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Gross	8578.15	...	8578.15	9493.59	10.41	9504.00	9866.64	9.96	9876.60	9934.59	6.50	9941.09
Recoveries	-178.43	...	-178.43	...	...	...	...	...	...	...	...	...
Receipts	...	...	...	...	...	...	...	...	...	...	...	...
Net	**8399.72**	**...**	**8399.72**	**9493.59**	**10.41**	**9504.00**	**9866.64**	**9.96**	**9876.60**	**9934.59**	**6.50**	**9941.09**
Investment in Public Enterprise												
01 Agrinnovate India Limited	...	14.64	14.64	...	2.87	2.87	...	16.00	16.00	...	20.00	20.00

1. The provision is for the expenditure on salary and establishment expenditure of Department and Agricultural Scientists Recruitment Board (ASRB). ASRB is an attached office of DARE.
2. The provision is for the activities to reach out to the farmers at grass root level through Krishi Vigyan Kendras to disseminate and refine frontline agricultural technologies. It includes training of farmers and extension personnel on local technologies, distribution of seed, planting materials, testing of soil and water samples.
3. The provision is for research, development and refinement of farm equipment, process and value addition protocols.
4. The provision is for research to address low farm productivity and profitability, land degradation, low water productivity, soil health deterioration and low nutrient use efficiency, deterioration in ecosystem services, abiotic stresses, etc. It is necessary to encounter deteriorating natural resource base for long term sustainability.
5. The provision is to conduct strategic research and technology demonstration to enhance resilience of Indian agriculture to climate change and climate vulnerability. The research on adaptation

(Continued)

(Concluded)

and mitigation covers crops, livestock, fisheries and natural resource management.This scheme will be merged with Natural Resource Management Institutes including Agro Forestry Research scheme with effect from financial year 2023-24.

6. Research provision is to develop trait- specific high yielding field crop varieties/hybrids having tolerance to pest and diseases, besides various abiotic stresses. The quality attributes are also given due importance with no yield penalty. The All India Coordinated Research Project (AICRPs)/Network Research Projects with active collaboration with State Agricultural Universities (SAUs) are engaged in the development of improved crop varieties/ hybrids, cost-effective production and environment-friendly protection technologies in different agro-climatic regions.
7. The provision is to address thrust areas of enrichment of horticultural genetic resources, development of new cultivation with resistance mechanism to biotic and abiotic stresses, appropriate production technology and health management system of horticultural and vegetable crops.
8. Supports basic and strategic research in agriculture to address the prioritized research problems. This scheme will be merged under non scheme budget with effect from 2023-24
9. The provision is to develop new technologies to support production enhancement, profitability, competitiveness and sustainability of livestock and poultry sector for food and nutritional security. It will facilitate need based priority research in livestock and poultry sector in on-going and new emerging areas to support productivity increase, thereby reducing the gap between potential and actual yield.
10. The provision is to implement research and academic programmes in fisheries and aquaculture. It also provides technical, training, analytical, advisory support and consultancy services in the field of resources assessment and management, standardization of aquaculture hatchery and grow-out culture technologies, responsible fishing system and species diversification and utilization of inland saline soils for aquaculture, fish health monitoring, etc.
11. The provision will provide financial support to all the agricultural universities in the country comprising State Agricultural Universities (SAUs), Deemed Universities (DUs), and Central Universities (CUs) with Agriculture Faculty. The scheme is also responsible for maintainance and improvement of standard of agricultural education through:(i) accreditation of educational institutions, (ii) providing International/national fellowships both at post and undergraduate levels, (iii) organization of training and capacity building programmes for the scientists/faculty of National Agricultural Research System in cutting-edge areas.
12. It is an externally aided project funded by World Bank and the Government. The provision is for the externally aided component of the National Agricultural Higher Education Project (NAHEP) which aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, providing means for better governance and management of agricultural universities, so that a holistic model can be developed to raise the standard of current agricultural education system that provides more jobs and is entrepreneurship oriented on par with global agricultural standards.
13. The provision is for the activities to reach out to the farmers at grass root level through Krishi Vigyan Kendras to demonstrate disseminate and refine front-line agricultural technologies. It includes demonstration of technologies, training of farmers and extension personnel on local technologies, distribution of seed, planting materials, testing of soil and water samples etc.
14. The provision is for research, development and refinement of farm equipment, process and value addition protocols.
15. The provision is for conducting research to address low farm productivity and profitability, land degradation, low water productivity, soil health deterioration and low nutrient use efficiency, deterioration in ecosystem services, abiotic stresses, etc. It is necessary to encounter deteriorating natural resource base for long-term sustainability of agricultural development.
16. Research provision is to develop trait- specific high yielding field crop varieties/hybrids having tolerance to pest and diseases and bio-fortification, besides various abiotic stresses. The quality attributes are also given due importance with no yield penalty. The All India Coordinated Research Project (AICRPs)/Network Research Projects with active collaboration with State Agricultural Universities (SAUs) are engaged in the development of improved crop varieties/ hybrids, cost-effective production and environment-friendly protection technologies in different agro-climatic regions.
17. The provision is to address thrust areas of enrichment of horticultural genetic resources, development of new cultivation with resistance mechanism to biotic and abiotic stresses, appropriate production technology and health management system of horticultural and vegetable crops.
18. The provision is to develop new technologies to support production enhancement, profitability, competitiveness and sustainability of livestock and poultry sector for food and nutritional security. It will facilitate need based priority research in livestock and poultry sector in on-going and new emerging areas to support productivity increase, thereby reducing the gap between potential and actual yield.
19. The provision is to implement research and academic programmes in fisheries and aquaculture. It also provides technical, training, analytical, advisory support and consultancy services in the field of fisheries resources assessment and management, standardization of aquaculture hatchery and grow-out culture technologies, responsible fishing system and species diversification and utilization of inland saline soils for aquaculture, fish health monitoring, etc.
20. The provision will provide financial support to all the agricultural universities in the country comprising State Agricultural Universities (SAUs), Deemed Universities (DUs), and Central Universities (CUs) with Agriculture Faculty. The scheme is also responsible for maintenance and improvement of standard of agricultural education through:(i) accreditation of educational institutions, (ii) providing International/national fellowships both at post and undergraduate levels, (iii) Organization of training and capacity building programmes for the scientists/faculty of National Agricultural Research System in cutting-edge areas.
21. Provision is primarily for the salaries, pensions, expenses on administrative and logistic support to different schemes under ICAR in order to implement them efficiently.
22. The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation.
23. The provision is to provide a forum to Agricultural Scientists to deliberate on important issues of agricultural research, education, extension and present views of the scientific community as policy inputs to planners, decision/opinion makers at various levels.

APPENDIX 2

LIST OF THE MEMBERS OF THE GENERAL BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

4(i) Minister-in-charge of the portfolio of Agriculture & Farmers Welfare in the Union Cabinet-President of the Society.

President

1. Shri Shivraj Singh Chouhan — Ex-officio
Minister of Agriculture & Farmers Welfare & Rural Development, Government of India, Krishi Bhavan, New Delhi-110 001

4(ii) Minister of State in the Union Ministry of Agriculture & Farmers Welfare dealing with ICAR-Vice President of the Society

Vice President

2. Shri Bhagirath Choudhary — Ex-officio
Minister of State for Agriculture & Farmers Welfare, Government of India, Krishi Bhavan, New Delhi-110 001

4(iii) Union Ministers holding charge of Finance, Planning, Science & Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/Department concerned).

3 Smt. Nirmala Sitharaman — Ex-officio
Minister of Finance and Corporate Affairs, Government of India, North Block, New Delhi-110 001

4 Shri Piyush Goyal — Ex-officio
Minister of Commerce & Industry, Government of India, Udyog Bhavan, New Delhi-110 001

5 Shri Dharmendra Pradhan — Ex-officio
Minister of Education, Government of India, Shastri Bhavan, New Delhi-110 001

6 Dr. Jitendra Singh — Ex-officio
Minister of State (IC) of the Ministry of Science & Technology and Earth Sciences, Government of India, CSIR Building, 2 Rafi Marg, New Delhi-110 001

7 Shri Rao Inderjit Singh — Ex-officio
Minister of State (IC) of the Ministry of Statistics & Programme Implementation, Planning and Minister of State in the Ministry of Culture, Government of India, Room No. 132, NITI Aayog, New Delhi-110 001

4(iv) Other Ministers in the Union Ministry of Agriculture & Farmers Welfare.

8 Shri Ram Nath Thakur — Ex-officio
Minister of State for Agriculture & Farmers Welfare, Government of India, Krishi Bhavan, New Delhi-110 001

4(v) Union Minister and Minister of State(s) in the Union Ministry of Fisheries, Animal Husbandry & Dairying

Union Minister of Fisheries, Animal Husbandry & Dairying will be the Senior Vice-President.

Senior Vice-President

9 Shri Rajiv Ranjan Singh alias Lalan Singh — Ex-officio
Minister of Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

10 Prof. S. P. Singh Baghel — Ex-officio
Minister of State for Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

11 Shri George Kurian — Ex-officio
Minister of State for Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

4(vi) Ministers in the States in-charge of Agriculture/Horticulture/Animal Husbandry/Fisheries.

ANDHRA PRADESH

12 Shri Kinjarapu Atchannaidu — Ex-officio
Minister for Agriculture, Co-operation, Marketing, Animal Husbandry, Dairy Development & Fisheries, Government of Andhra Pradesh, Room No. 130, Ground Floor, Bulding No. 4, Velagapudi, Amaravathi, Andhra Pradesh-522 503

ARUNACHAL PRADESH

13 Shri Gabriel Denwang Wangsu — Ex-officio
Minister for Agriculture, Animal Husbandry & Veterinary, Dairy Development, Horticulture & Fisheries, Government of Arunachal Pradesh, Room No-308, Block-II, Civil Secretariat, Itanagar, Arunachal Pradesh-791 111

ASSAM

14 Shri Atul Bora — Ex-officio
Minister for Agriculture Horticulture & Animal Husbandry, Government of Assam, Assam (Civil) Secretariat, Dispur, Guwahati, Assam-781 006

15 Shri Parimal Suklabaiya — Ex-officio
Minister of Fisheries, Government of Assam, Assam (Civil) Secretariat, Dispur, Guwahati, Assam-781 006

BIHAR

16 Shri Mangal Pandey — Ex-officio
Hon’ble Minister for Agriculture, Government of Bihar, Vikas Bhavan, New Secretariat, Bailey Road, Patna, Bihar-800 015

17 Smt. Renu Devi — Ex-officio
Hon’ble Minister for Animal & Fisheries Resources, Government of Bihar, Vikas Bhavan, New Secretariat, Bailey Road, Patna, Bihar-800 015

CHHATTISGARH

18 Shri Ramvichar Netam — Ex-officio
Minister of Agriculture, Animal Husbandry & Fisheries, Government of Chhattisgarh, Mahanadi Bhawan, Mantralaya, Naya Raipur, Chhattisgarh-492 002

DELHI

19 VACANT

GOA

20 Shri Ravi Naik Ex-officio
Minister of Agriculture, Government of Goa, Secretariat, Porvorim, Goa-403 521

21 Sh. Nilkanth Halarnkar Ex-officio
Minister of Animal husbandry & Veterinary Sciences & Fisheries, Government of Goa, Secretariat, Porvorim, Goa-403 521

GUJARAT

22 Shri Raghavjibhai Hansrajbhai Patel Ex-officio
Minister for Agriculture, Animal Husbandry & Fisheries, Government of Gujarat, Swarnim Sankul-1, 2nd Floor, Sachivalaya, Sector-10, Gandhinagar, Gujarat-382 010

HARYANA

23 Shri Shyam Singh Rana Ex-officio
Minister for Agriculture and Farmer Welfare, Horticulture, Animal Husbandry and Fisheries, Government of Haryana, Room No. 47, 8th Floor, Haryana Civil Secretariat, Chandigarh, Haryana-160 001

HIMACHAL PRADESH

24 Shri Chander Kumar Ex-officio
Minister for Agriculture & Animal Husbandry & Cooperation, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002

25 Shri Jagat Singh Negi Ex-officio
Minister for Horticulture, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002

JHARKHAND

26 Smt. Shilpi Neha Tirkey Ex-officio
Minister of Agriculture and Animal Husbandry & Cooperation, Government of Jharkhand, Project Building HEC, Dhurva, Ranchi, Jharkhand-834 002

KARNATAKA

27 Sri N. Chaluvarayaswamy Ex-officio
Minister for Agriculture, Government of Karnataka, Vikasa Soudha, Bengaluru, Karnataka-560 001

28 Sri S. S. Mallikarjun Ex-officio
Minister for Horticulture, Government of Karnataka, Vikasa Soudha, Bengaluru, Karnataka-560 001

29 Sri K. Venkatesh Ex-officio
Minister of Animal Husbandry, Government of Karnataka, Vidhana Soudha, Dr. B. R. Ambedkar Veedhi, Bengaluru, Karnataka-560 001

30 Sri Mankal Vaidya Ex-officio
Minister of Fisheries, Government of Karnataka, Vidhana Soudha, Dr. B. R. Ambedkar Veedhi, Bengaluru, Karnataka-560 001

KERALA

31 Shri P. Prasad Ex-officio
Minister for Agriculture, Government of Kerala, Government Secretariat Annexe-2, Thiruvananthapuram, Kerala-695 001

32 Smt. J. Chinchu Rani Ex-officio
Minister for Animal Husbandry, Government of Kerala Government Secretariat Annexe-2, Thiruvananthapuram, Kerala-695 001

33 Shri. Saji Cherian Ex-officio
Minister for Fisheries, Government of Kerala, Government Secretariat Annexe-1, Thiruvananthapuram, Kerala-695 001

MADHYA PRADESH

34 Shri Adal Singh Kansana Ex-officio
Minister for Farmers' Welfare and Agriculture Development, Government of Madhya Pradesh, Room No. B-106, VB-II, Mantralaya, Vallabh Bhavan, Bhopal, Madhya Pradesh-462 004

35 Shri Lakhan Singh Patel Ex-officio
Minister of State (Independent Charge) for Animal Husbandry and Dairying, Government of Madhya Pradesh, Room No. E-205, VB-III, Mantralaya, Vallabh Bhavan, Bhopal, Madhya Pradesh-462 004

36 Shri Narayan Singh Panwar Ex-officio
Minister of State (Independent Charge) for Fishermen Welfare and Fisheries Development, Room No. D-507, VB-III, Mantralaya, Vallabh Bhavan, Bhopal, Madhya Pradesh-462 004

37 Shri Narayan Singh Kushwah Ex-officio
Minister for Horticulture and Food Processing, Government of Madhya Pradesh, Room No. B-427, VB-II, Mantralaya, Vallabh Bhavan, Bhopal, Madhya Pradesh-462 004

MAHARASHTRA

38 Shri Adv. Manikrao Saraswati Shivaji Kokate Ex-officio
Minister for Agriculture, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

39 Shri Bharat Gogale Ex-officio
Minister for Horticulture, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

40 Ms. Pankaja Munde Ex-officio
Minister for Animal Husbandry, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

41 Shri Nitish Rane Ex-officio
Minister for Fisheries, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

MANIPUR

42 Shri Thongam Biswajit Singh Ex-officio
Minister for Agriculture, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

43 Sh. Letpao Haokip Ex-officio
Minister for Horticulture, Room No. 214, South Block, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

44 Shri Heikham Dingo Singh Ex-officio
Minister for Fisheries, Room No. 316-318, South Block, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

45 Shri Khashim Vashum Ex-officio
Minister for Animal Husbandry, Government of Manipur, Manipur Secretariat, Imphal, Manipur-795 001

MEGHALAYA

46 Dr. Mazel Ampareen Lyngdoh Ex-officio
Minister for Agriculture & Farmers' Welfare, Government of Meghalaya, Meghalaya Secretariat, Main Building, Shillong, Meghalaya-793 001

47 Shri Alexander Laloo Hek Ex-officio
Minister for Animal Husbandry & Fisheries, Government of Meghalaya, Meghalaya Secretariat, Main Building Shillong, Meghalaya-793 001

MIZORAM

48 Prof. Lalnilawma Ex-officio
Minister for Horticulture, Government of Mizoram, Mizoram Secretariat, MINECO, Khatla, Aizawl, Mizoram-796 001

49 Shri C. Lalsawivunga Ex-officio
Minister for Animal Husbandry & Dairying, Government of Mizoram, Mizoram Secretariat, MINECO, Khatla, Aizawl, Mizoram-796 001

50 Shri P. C. Vanlalruata Ex-officio
Minister for Agriculture, Government of Mizoram, Mizoram Secretariat, MINECO, Khatla, Aizwal, Mizoram-796 001

51 Shri Lalthansanga Ex-officio
Minister for Fisheries, Government of Mizoram, Mizoram Secretariat, MINECO, Khatla, Aizwal, Mizoram-796 001

NAGALAND

52 Shri Mhathung Yanthan Ex-officio
MLA & Advisor to the Deptt. of Agriculture, Government of Nagaland, New Secretariate Complex, Kohima, Nagaland-797 001

53 Shri A. Pangjung Jamir Ex-officio
MLA & Advisor to the Deptt. of Fisheries & Aquatic Resources, Government of Nagaland, New Secretariate Complex, Kohima, Nagaland-797 001

54 Shri Kazheto Ex-officio
MLA & Advisor to the Deptt. of Animal Husbandry, Government of Nagaland, New Secretariate Complex, Kohima, Nagaland-797 001

55 Smt. Salhoutuonuo Kruse Ex-officio
Minister for Human Resource Development & Horticulture Government of Nagaland, New Secretariate Complex, Kohima, Nagaland-797 001

ODISHA

56 Shri K.V. Singh Deo Ex-officio
Deputy Chief Minister, Agriculture & Farmers Empowerment Department, Government of Odisha, Odisha Secretariat Bhubaneswar, Odisha-751 001

57 Shri Gokulananda Mallik Ex-officio
Minister for Fisheries & Animal Resources Development, Government of Odisha, Odisha Secretariat, Bhubaneswar, Odisha-751 001

PUNJAB

58 Shri Gurmeet Singh Khudian Ex-officio
Minister for Agriculture & Farmers' Welfare, Animal husbandry, Fisheries and Dairy Development, Government of Punjab, Punjab Civil Secretariat-1, Chandigarh, Punjab

PUDUCHERRY

59 Shri C. Djeacoumar Ex-officio
Minister of Agriculture & Animal Husbandry, Government of Puducherry, Puducherry-605 001

60 Shri. K. Lakshminarayanan Ex-officio
Minister for Fisheries and Fishermen Welfare, Government of Puducherry, Puducherry-605 001

RAJASTHAN

61 Dr. Kirori Lal Meena Ex-officio
Minister for Agriculture & Horticulture, Government of Rajasthan, Rajasthan Secretariat, Mantralaya Bhawan, Jaipur, Rajasthan-302 005

62 Shri Joraram Kumawat Ex-officio
Minister for Animal Husbandry & Dairy, Government of Rajasthan, Rajasthan Secretariat, Mantralaya Bhawan, Jaipur, Rajasthan-302 005

SIKKIM

63 Shri Puran Kumar Gurung Ex-officio
Minister for Agriculture, Animal Husbandry & Veterinary Services, Horticulture & Fisheries, Government of Sikkim, New Secretariat, Development Area, Gangtok, Sikkim-737 101

TAMIL NADU

64 Shri M.R.K. Panneerselvam Ex-officio
Minister for Agriculture & Horticulture, Government of Tamil Nadu, Chennai, Tamil Nadu-600 009

65 Shri Anitha R. Radhakrishnan Ex-officio
Minister for Fisheries, Fisheries Development Corporation and Animal Husbandry, Government of Tamil Nadu, Chennai, Tamil Nadu-600 009

TELANGANA

66 Shri Tummala Nageswara Rao Ex-officio
Minister of Agriculture, Government of Telangana, Haka Bhawan, 2nd Floor, Nampally, Telangana Secretariat, Hyderabad, Telangana-500 004

TRIPURA

67 Shri Ratan Lal Nath Ex-officio
Minister for Agriculture & Farmers' Welfare, Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001

68 Sh. Sudhangshu Das Ex-officio
Minister for Animal Resource Development and Fisheries, Government of Tripura, Civil Secretariat, Agartala, Tripura-799 001

UTTARAKHAND

69 Shri Ganesh Joshi Ex-officio
Minister for Agriculture, Government of Uttarakhand, Uttarakhand Vidhan Sabha Bhawan, Dehradun, Uttarakhand

70 Shri Saurabh Bahuguna Ex-officio
Minister for Animal Husbandry & Fisheries, Government of Uttarakhand, Uttarakhand Vidhan Sabha Bhawan, Dehradun, Uttarakhand

UTTAR PRADESH Ex-officio

71 Shri Surya Pratap Shahi
Minister of Agriculture, Agricultural Education & Agricultural Research, Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh

72 Shri Dharampal Singh Ex-officio
Minister of Animal Husbandry & Dairy Development, Government of Uttar Pradesh, UP Civil Secretariat, Lucknow, Uttar Pradesh

73 Shri Sanjay Kumar Nishad Ex-officio
Minister of Fisheries, Government of Uttar Pradesh, Room No. 89, Vidhan Sabha Main Building, UP Civil Secretariat, Lucknow, Uttar Pradesh

WEST BENGAL

74 Shri Sobhandeb Chattopadhyay Ex-officio
Minister for Agriculture, Government of West Bengal, Nabanna, 3rd Floor, 325, Sarat Chatterjee Road, Mandirtala, Shibpur, Howrah, Kolkata, West Bengal-711 102

75 Shri Swapan Debnath Ex-officio
Minister of Animal Resources Development, Government of West Bengal, Prani Sampad Bhavan, LB-2, Sector-III, Salt Lake, Kolkata, West Bengal-700 106

76 Shri Biplab Roy Chowdhury Ex-officio
Minister of State (IC) for Fisheries, Government of West Bengal, Benfish Tower, 8th Floor, 31 GN Block, Salt Lake, Sector-V, Kolkata, West Bengal-700 091

77 Shri Arup Roy Ex-officio
Minister-in-charge for Horticulture, Government of West Bengal, Benfish Tower, 4th Floor, GN Block, Sector V, Salt Lake City, Kolkata, West Bengal-700 091

4(vii) Member, NITI Ayog, In-charge of Agriculture.
78 Prof. Ramesh Chand Ex-officio
Member (Agriculture), NITI Ayog, Niti Bhawan, New Delhi-110 001

79 VACANT (due to office of profit)

4(viii) Six Members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha.
80 VACANT -do-

81 VACANT -do-

82 VACANT -do-

83 VACANT -do-

84 VACANT -do-

4(ix) Director-General, Indian Council of Agricultural Research.
85 Dr. Himanshu Pathak Ex-officio
Secretary (DARE) and DG (ICAR), Krishi Bhavan, New Delhi-110 001

4(x) All Secretaries in the Ministry of Agriculture & Farmers Welfare.
86 Shri Devesh Chaturvedi Ex-officio
Secretary, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhavan, New Delhi-110 001

4(xi) All Secretaries in the Ministry of Fisheries, Animal Husbandry & Dairying.
87 Dr. Abhilaksh Likhi, Ex-officio
Secretary, Department of Fisheries, Ministery of Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

88 Ms. Alka Upadhyaya Ex-officio
Secretary, Department of Animal Husbandry and Dairying, Ministery of Fisheries, Animal Husbandry and Dairying, Government of India, Krishi Bhavan, New Delhi-110 001

4(xii) CEO, NITI Ayog
89 Shri B.V.R. Subrahmanyam Ex-officio
CEO, Niti Aayog, Yojana Bhavan, Sansad Marg, New Delhi-110 001

4(xiii) Secretary, Department of Bio-technology.
90 Dr. Rajesh S. Gokhale Ex-officio
Secretary, Department of Biotechnology, Block 2, 7th Floor, CGO Complex, Lodhi Road, New Delhi-110 003

4(xiv) Director-General, Council of Scientific and Industrial Research.
91 Dr. (Mrs.) N. Kalaiselvi Ex-officio
Director General, Council of Scientific and Industrial Research, Anusandhan Bhavan, 2-Rafi Ahmed Kidwai Marg, New Delhi-110 001

4(xv) Chairman, University Grants Commission.
92 Prof. M. Jagadesh Kumar Ex-officio
Chairman, University Grants Commission, Bahadur Shah Zafar Marg, New Delhi-110 002

4(xvi) Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)
93 Dr. Ajit Kumar Mohanty Ex-officio
Chairman, Atomic Energy Commission, Department of Atomic Energy, Anushakti Bhavan, Chhatrapati Shivaji Maharaj Marg, Mumbai, Maharashtra-400 001
4(xvii) Member, Finance (Secretary/Additional Secretary) in the Ministry of Finance, Government of India. Alternative member for Ministry of Finance-AS & FA (DARE/ICAR)
94 Shri Manoj Govil Ex-officio
Secretary (Expenditure), Department of Expenditure, Ministry of Finance, North Block, New Delhi-110 001

Alternative member for Ministry of Finance, AS & FA (DARE/ICAR)
95 Mrs. Alka Arora Ex-officio
Additional Secretary & FA (DARE/ICAR), Krishi Bhawan, New Delhi-110 001

4(xviii) Five Vice-Chancellors of Agricultural Universities, nominated by the President.
96 Dr. Rajeshwar Singh Chandel 05.06.2025
Vice-Chancellor, Dr. Y. S. Parmar University of Horticulture & Forestry, Solan, Nauni, Himachal Pradesh-173 230

97 Dr. P. S Pandey 29.09.2025
Vice-Chancellor, Dr. Rajendra Prasad Central Agricultural University, Smastipur, Bihar-848 125

98 Prof Balraj Singh 13-03-2026
Vice-Chancellor, Sri Karan Narendra Agriculture University, Jobner, Rajasthan-303 329

99 Dr. S. C. Dubey 15-04-2027
Vice-Chancellor, Birsa Agricultural University, Ranchi, Jharkhand-834 006

100 VACANT

4(xix) Five technical representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner and Fisheries Development Commissioner from Union Ministries of Agriculture & Farmers Welfare/Fisheries, Animal Husbandry & Dairying and Inspector-General of Forests, Government of India.
101 Dr. Praveen Kumar Singh Ex-officio
Agriculture Commissioner, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhawan, New Delhi-110 001

102 Dr. Prabhat Kumar Ex-officio
Horticulture Commissioner, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Krishi Bhawan, New Delhi-110 001

103 Dr. Abhijit Mitra Ex-officio
Animal Husbandry Commissioner, Department of Animal Husbandry & Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Chander Lok Building, Janpath, New Delhi-110 001

104 Dr. K. Mohammed Koya Ex-officio
Fisheries Development Commissioner, Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, Krishi Bhawan, New Delhi-110 001

105 Sh. Ramesh Kumar Pandey Ex-officio
Inspector General of Forests (NAEB), Ministry of Environment & Forests, Paryavaran Bhawan, B-Block, CGO Complex, Lodi Road, New Delhi-110 003

4(xx) Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research, nominated by the President.

106 VACANT --

107 VACANT --

108 VACANT --

109 VACANT --

110 VACANT --

111 VACANT --

112 VACANT --

113 VACANT --

114 VACANT --

115 VACANT --

116 Dr. Arun Kumar Das 11.10.2025
Retd. Professor and Head, Flat No. 4102, Terra Block, Dnoxy park, Dumduma, P.O. Khandagiri, Bhubaneswar, Odisha-751 030

117 Dr. Purushottam Ramniwas Zanwar 11.10.2025
Associate Professor (Agricultural Entomology), Department of Agricultural Entomology, College of Agriculture, VNMKV, Parbhani, Maharashtra-431 402

118 Dr. Vinod Singh 11.10.2025
Department of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh-224 229

119 Dr. Rajendra Singh Rajput 11.10.2025
B-17/4, Vasant Vihar, Ujjain, Madhya Pradesh-456 010

Representative from the Indian Council of Medical Research

120 Dr. Bharati Kulkarni 31.10.2025
Scientist G & Head, Division of Reproductive Biology, Maternal & Child Health & Nutrition, Indian Council of Medical Research, V. Ramalingaswami Bhawan, Ansari Nagar, New Delhi-110 029

4(xxi) Three representatives of commerce and industry, nominated by the President.

121 Shri Lokendra Singh 13-07-2026
Salwa, Tehsil Badnagar, Ujjain, Madhya Pradesh-456 313

122 Shri Arun Mandal 13-07-2026
S/O Dinesh Ch. Mandal, Vill-Sahadargachh, P.O. Bidhannagar, PS-Phansidewa, Dist-Darjeeling, West Bengal-734 426

123 Dr. Kernel Singh Risam 13-07-2026
171/7 Nanak Nagar, Jammu-180 004

4(xxii) One farmer from each region of the country as mentioned in Rule 60(a) and four representatives of rural interests, nominated by the President.

(Representative of Region-I)

124 VACANT --

(Representative of Region-II)

125 Dr. Bhaskar Naik Karamsi 13.07.2026
Door No. 11-2-380
Naik Nagar, Beside Marremma Temple
Ananthapuramu, Andhra Pradesh-515 001

(Representative of Region-III)

126 Prof. (Dr.) Kishore Kumar Baruah 13.07.2026
Sai Sai Villa, Kanaklata Road, Narayan Nagar, Kumarpara, PO Bharalumukh, Guwahati, Assam-781 009

(Representative of Region-IV)

127 Sh. Venugopal Badaravada, 7.9.2026
Shri Yama Aditya Temple, Manikarnika Kshetra, Sankatha Ghat, Varanasi, Uttar Pradesh-221 001

(Representative of Region-V)

128 Shri R. K. Sangwan 13.07.2026
H. No. 108B, South City-2, Gurugram, Haryana-122 018

(Representative of Region-VI)

129 VACANT --

(Representative of Region-VII)

130 Shri Rahul Manikrao Shinde 13.07.2026
C-603, Sapphire Park, Nr Wisdom World School Park Street, Wakad, Pune, Maharashtra-411 057

(Representative of Region-VIII)

131 VACANT --

Four Representatives of Rural Interests, nominated by the President.

132 VACANT --

133 VACANT --

134 VACANT --

135 VACANT --

4(xxiii) Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President.

136 Dr. Triveni Dutt 15.03.2025
Director, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh-243 122

137 Dr. R. A. Marathe 15.03.2025
Director, National Research Center on Pomegranate, Solapur, NH-65, Solapur-Pune Highway, Kegaon, Solapur, Maharashtra-413 255

138 Dr. Dheer Singh 15.04.2027
Director, ICAR-National Dairy Research Institute, Karnal, Haryana-132 001

139 Dr. Maganti Sheshu Madhav 15.04.2027
Director, ICAR- ICAR-National Institute for Research on Commercial Agriculture (NIRCA), Bhaskar Nagar, Rajahmundry, Andhra Pradesh-533 105

4(xxiv) Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

140 Secretary 23.07.2026
Deptt. of Agriculture & Horticulture, Government of Uttarakhand, Secretariat, 4-Subhash Road, Dehradun, Uttarakhand

141 Additional Chief Secretary 23.07.2026
Agriculture Department Government of Assam, D-Block, 3rd Floor, Janata Bhawan, Dispur, Guwahati, Assam-781 006,

142 Additional Chief Secretary, 23.07.2026
Department of Agriculture & Farmer Welfare, Government of Haryana, Krishi Bhawan, Sector 21, Budhanpur, Panchkula, Haryana-134 117

143 Agriculture Production Commissioner 23.07.2026
2nd Floor, C- Wing, Vindhyachal Bhawan, Arera Hills, Bhopal, Madhya Pradesh-462 004

4(xxv) One representative of Agro and Agro-Processing Industries, nominated by President

144 Shri Kanwal Singh Chauhan 13.09.2025
Shimla Farm, Village-Aterna, Distt. Sonipat, Haryana-131 023

4(xxvi) One representative from a distinguished Non-Governmental Organization dealing with Agriculture/ Extension, Nominated by President

145 Mrs. Sushma Singh 10-07-2026
6/127, 2nd Floor, Vineet Khand (Opposite Water Tank), Near Husadiya Chauraha, Gomti Nagar, Lucknow, Uttar Pradesh-226010
Postal Address:
Mrs. Sushma Singh
Flat No.-1602/Tower No.-01
Sunworld Vanallika Apartments
Sector 107, Noida, Uttar Pradesh-201 304

4(xxvii) Secretary, Indian Council of Agricultural Research - Member Secretary

146 Shri Sanjay Garg Ex-Officio
Additional Secretary (DARE) & Secretary (ICAR), Krishi Bhavan, New Delhi-110 001

❑

APPENDIX 3

LIST OF THE MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Rule 35(i)
Chairman

1. Dr. Himanshu Pathak — Ex-Officio
   Secretary (DARE) & Director-General, Indian Council of Agricultural Research, Krishi Bhawan, New Delhi-110 001

Ex-Officio Members
Rule 35(ii)
Member, Finance, Alternate member -Financial Adviser (DARE/ICAR)

2. Dr. Manoj Govil — Ex-Officio
   Secretary (Expenditure), Department of Expenditure, 129-A, North Block, Ministry of Finance, North Block, New Delhi-110 001

Alternate member-Financial Adviser (DARE/ICAR)

Mrs. Alka Arora, — Ex-Officio
Additional Secretary & Financial Advisor (DARE/ICAR), Krishi Bhavan, New Delhi 110 001

Rule 35(iii)
Chief Executive Officer, National Institution for Transforming India (NITI Aayog) or representative (not lower than the rank of Joint Secretary)

3. Shri B.V.R. Subrahmanyam — Ex-Officio
   CEO, NITI Aayog, Yojana Bhavan, Sansad Marg, New Delhi-110 001

Rule 35(iv)
Secretary, Department of Agriculture Cooperation & Farmers Welfare

4. Shri Devesh Chaturvedi — Ex-Officio
   Secretary Department of Agriculture & Farmers Welfare, Ministry of Agriculture, Krishi Bhavan, New Delhi-110 001

Rule 35(v)
Secretary, Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying

5. Ms. Alka Upadhyaya — Ex-Officio
   Secretary, Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Krishi Bhavan, New Delhi-110 001

Rule 35(vi)
Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying

6. Dr. Abhilaksh Likhi, — Ex-Officio
   Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Krishi Bhavan, New Delhi-110 001

Rule 35(vii)
Three Scientists including one management expert from outside ICAR nominated by the President

7. Dr. Arun Kumar Das — 11.10.2025
   (management expert) Retd. Professor and Head, Flat No. 4102, Terra Block, Dnoxypark, Dumduma. P.O. Khandagiri, Bhubaneswar, Odisha-751 030
8. VACANT — -
9. VACANT — -

Rule 35 (viii)
Five Vice-Chancellors of Agricultural Universities-nominated by the President

10. VACANT — -
11. Dr Rajeshwar Singh Chandel — 05.06.2025
    Vice Chancellor, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh
12. Prof Balraj Singh — 13-03-2026
    Vice-Chancellor, Sri Karan Narendra Agriculture University, Jobner, Rajasthan-303 329
13. Dr. Punyavrat S. Pandey, — 29.09.2025
    Vice Chancellor, Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar-848 125
14. Dr. S. C. Dubey — 15.04.2027
    Vice Chancellor, Birsa Agricultural University, Ranchi, Jharkhand-834 006

Rule 35(ix)
Three Members of Parliament nominated by the President- (Two from Lok Sabha and one from Rajya Sabha)

15. VACANT
16. VACANT
17. VACANT

Rule 35(x)
Four Farmers/Representatives of Rural Areas nominated by the President

18. Shri R. K. Sangwan — 13.07.2026
    H. No. 108B, South City-2, Gurugram, Haryana-122 018
19. Sh. Venugopal Badaravada, — 7. 9. 2026
    Shri Yama Aditya Temple, Manikarnika Kshetra, Sankatha Ghat, Varanasi, Uttar Pradesh-221 001
20. VACANT
21. VACANT

Rule 35(xi)
Three Directors of Research Institutes of the Council nominated by the President

22. Dr. Triveni Dutt — 15.3.2025
    Director, ICAR-Indian Veterinary Research Institute, Bareilly, Uttar Pradesh-243 122
23. Dr. Dheer Singh, — 15.04.2027
    Director, ICAR-National Dairy Research Institute, Karnal, Haryana-132 001
24. Dr. Maganti Sheshu Madhav — 15.04.2027
    Director, ICAR-National Institute for Research on Commercial Agriculture (NIRCA), Bhaskar Nagar, Rajahmundry, Andhra Pradesh-533 105

Rule 35(xii)

Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

25. Secretary, Department of Agriculture & Horticulture Government of Uttarkhand Secretariat, 4-Subhash Road, Dehradun, Uttarkhand — 23.07.2026

26. Additional Chief Secretary, Agriculture Department, Government of Assam D-Block, 3rd Floor Janata Bhawan, Dispur, Guwahati, Assam-781 006 — 23.07.2026

27. Additional Chief Secretary, Department of Agriculture & Farmers Welfare Government of Haryana, Krishi Bhawan, Sector 21, Budhanpur, Panchkula, Haryana-134117 — 23.07.2026

28. Agriculture Production Commissioner 2nd Floor, C- Wing, Vindhyachal Bhawan, Arera Hills, Bhopal, Madhya Pradesh-462 004 — 23.07.2026

Rule 35(xiii)

One representative of Agro and Agro-Processing Industries to be nominated by President

29. Sh. Kanwal Singh Chauhan R/O Shimla Farm, Vill. Aterna, Sonipat, Haryana-131 023 — 13.09.2025

Rule 35(xiv)

One representative from a distinguished Non-Governmental Organization dealing with Agriculture/Extension nominated by President

30. Mrs. Sushma Singh, 6/127, 2nd Floor, Vineet Khand (Opposite Water Tank), Near Husadiya Chauraha, Gomti Nagar, Lucknow, Uttar Pradesh-226 010 — 10.07.2026

Postal Address:
Mrs. Sushma Singh
Flat No.-1602/Tower No.-01
Sunworld Vanallika Apartments
Sector 107, Noida, Uttar Pradesh-201 304

Rule 35(xv)

Secretary, ICAR-Member Secretary

31. Shri Sanjay Garg, Additional Secretary, DARE & Secretary, ICAR, Krishi Bhawan, New Delhi- 110 001 — Ex-Officio

❑

APPENDIX 4

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. **Dr. Himanshu Pathak**
   Director General, ICAR and Secretary to the Government of India, Department of Agricultural Research and Education
2. **Shri Sanjay Garg**
   Secretary, ICAR and Additional Secretary to Government of India, Department of Agricultural Research and Education
3. **Ms Alka Nangia Arora**
   Financial Adviser, ICAR and Additional Secretary to Government of India, Department of Agricultural Research and Education

Deputy Director Generals

1. Dr. Joykrushna Jena
   (Fisheries Science)
2. Dr. Sanjay Kumar Singh
   (Horticulture Science)
3. Dr. Suresh Kumar Chaudhari
   (Natural Resource Management)
4. Dr. Raghevendra Bhatta
   (Animal Science)
5. Dr. Tilak Raj Sharma
   (Crop Science)
6. Dr. Rakesh Chandra Agarwal
   (Agricultural Education & National Director, NAHEP)
7. Dr. Shyam Narayan Jha
   (Agricultural Engineering)
8. Dr. Udham Singh Gautam
   (Agricultural Extension)

Assistant Director Generals

Crop Science

1. Dr. Prasanta Kumar Dash (CC)
2. Dr. Sanjeev Gupta (OP)
3. Dr. Devendra Kumar Yadava (Seed)
4. Dr. Poonam Jasrotia, ADG (PP&B)
5. Dr. Sharat Kumar Pradhan (FFC)

Horticulture Science

1. Dr. Vishaw Bandhu Patel (FPCHS-I)
2. Dr. Sudhakar Pandey (FVS&MP) (HS-II)

Natural Resource Management

1. Dr. Rajbir Singh (AAF&CC)
2. Dr. A. Velmurugan (S&WM)

Agricultural Engineering

1. Dr. Kairam Narsaiah (PE)
2. Dr. Krishna Pratap Singh (FE)

Animal Science

1. Dr. Amrish Kumar Tyagi (AN&P)
2. Dr. Divakar Hemadri (AH)
3. Dr. Gyanendra Kumar Gaur (APB)

Fisheries Science

1. Dr. Devika Pillai (IF)
2. Dr. Shubhadeep Ghosh (MF)

Agricultural Extension

1. Dr. Rajarshi Roy Burman (AE)
2. Dr. Ranjay Kumar Singh (AE)

Agricultural Education

1. Dr. (Mrs.) Seema Jaggi, ADG (HRD)
2. Dr. Shanti Kumar Sharma (HRM)
3. Dr. Ajit Singh Yadav (EQAR)
4. Dr. Bimlesh Mann (EP&HS)

Others Units

1. Dr. Neeru Bhooshan (IPTM&PME)
2. Dr. Atmakuri Ramakrishna Rao (PIM)
3. Dr. Bikash Mandal (IR)
4. Dr. Anil Rai (ICT)
5. Dr. Anil Kumar (TC)

National Agricultural Science Fund (NASF)

1. Dr. Jitendra Kumar, ADG (NASF)

Principal Scientists

Crop Science

1. Dr. S. K. Jha
2. Dr. P. R. Chaudhary
3. Dr. Renu
4. Dr. Ishwar Singh
5. Dr. Pawan Kumar Sharma

Horticulture Science

1. Dr. Vikramaditya Pandey
2. Dr. Anup Kumar Bhattacharjee
3. Dr. Prakash Chandra Tripathi

Natural Resource Management

1. Dr. Adlul Islam
2. Dr. B.P. Bhatt
3. Dr. Ram Swaroop Yadav
4. Dr. Rakesh Kumar

Agricultural Education

1. Dr. (Mrs.) Vanita Jain
2. Dr. Kanhiaya Prasad Tripathi
3. Dr. (Ms) Smita Sirohi
4. Dr. Sita Ram Sharma
5. Dr. Dinesh Chand
6. Dr. Navin Kumar Jain

Fisheries Science

1. Dr. (Mrs.) Yasmeen Basade
2. Dr. Prem Kumar

Agricultural Engineering

1. Dr. Devendra Dhingra
2. Dr. Abhay Kumar Thakur
3. Dr. Panna Lal Singh

Animal Sciences

1. Dr. Harvinder Kumar Narula
2. Dr. Rajneesh Rana
3. Dr. Keshab Barman

Agricultural Extension

1. Dr. Ved Parkash Chahal
2. Dr. Keshava
3. Dr. Sujeet Kumar Jha
4. Dr. Arvind Kumar

Others Units

1. Dr. A. P. Ruhil (ICT)
2. Dr. Himanshu (ICT)
3. Dr. Krishan Pal Singh (ICT)
4. Dr. Manoj Kumar Tripathi (PIM)
5. Dr. Basant Kumar Kandpal (PIM)
6. Dr. Manoj Kumar (PIM)
7. Dr. A. S. Mishra (Technical Coordination)
8. Dr. Sanjeev Panwar (Tech. Cdn.)
9. Dr. Shiv Datt (IPTM)
10. Dr. Vikram Singh (IPTM)
11. Dr. (Mrs.) Manju Gerard (NASF)
12. Dr. Ashok Kumar (NASF)
13. Dr. A. K. Misra (IR)
14. Dr. Anjani Kumar Jha (DKMA)
15. Dr. Pramod Kumar Rout (DG Office)
16. Dr. Praveen Malik (DG Office/Agrinnovate)

National Agricultural Higher Education Project (NAHEP)

1. Dr. Sanjay Singh Rathore
   (On the rolls of IARI, New Delhi), PS & NC

APPENDIX 5

ICAR INSTITUTES AND THEIR DIRECTORS

1. Dr. Ch. Srinivasa Rao
Indian Agricultural Research Institute, New Delhi-110 012
2. Dr. Triveni Dutt
Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh-243 122
3. Dr. Dheer Singh
National Dairy Research Institute, Karnal, Haryana-132 001
4. Dr. Ravishankar Chandragiri Nagarajarao
Central Institute of Fisheries Education, Jaiprakash Road, Seven Bungalow (Versova), Mumbai, Maharashtra-400 061
5. Dr. R.C. Agrawal
National Academy of Agricultural Research Management, Rajendranagar, Hyderabad, Telangana-500 030
6. Dr. Kotha Sammi Reddy
National Institute of Abiotic Stress Management, Malegaon, Baramati, Pune, Maharashtra-413 115
7. Dr. Sujay Rakshit
Indian Institute of Agricultural Biotechnology, Ranchi, Jharkhand-834 010
8. Dr. Probir Kumar Ghosh
National Institute of Biotic Stress Management, Baronda, Raipur, Chhattisgarh-493 225
9. Dr. Eaknath B. Chakurkar
Central Island Agricultural Research Institute, Post Box No. 181, Port Blair, Andaman & Nicobar Islands-744 101
10. Dr. O. P. Yadav
Central Arid Zone Research Institute, Jodhpur, Rajasthan-342 003
11. Dr. Champat Raj Mehta
Central Institute of Agricultural Engineering, Nabi Bagh, Berasia Road, Bhopal, Madhya Pradesh-462 038
12. Dr. Jagadish Sadanand Rane
Central Institute of Arid Horticulture, Bikaner, Rajasthan-334 006
13. Dr. Y. G. Prasad
Central Institute for Cotton Research, Post Bag No. 2, Shankar Nagar P.O., Nagpur, Maharashtra-440 010
14. Dr. Damodaran Thukkaram
Central Institute for Sub-tropical Horticulture, Rehmankhera, PO Kakori, Lucknow, Uttar Pradesh-227 107
15. Dr. Mahendra Kumar Verma
Central Institute of Temperate Horticulture, Old Air Field, Rangreth, Jammu & Kashmir-190 007
16. Dr. Nachiket Kotwaliwale
Central Institute of Post-Harvest Engineering and Technology, P.O. PAU Campus, Ludhiana, Punjab-141 004
17. Dr. Sujeet Kumar Shukla
Central Institute for Research on Cotton Technology, Adenwala Road, Matunga, Mumbai, Maharashtra-400 019
18. Dr. K. Balachandra Hebbar
Central Plantation Crops Research Institute, Kasaragod, Kerala-671 124
19. Dr. Brajesh Singh
Central Potato Research Institute, Shimla, Himachal Pradesh-171 001
20. Dr. Vinod Kumar Singh
Central Research Institute for Dryland Agriculture, Santoshnagar, Saidabad P.O., Hyderabad, Telangana 500 059
21. Dr. Dinesh Babu Shakyawar
National Institute of Natural Fibre Engineering & Technology, 12, Regent Park, Kolkata, West Bengal-700 040
22. Dr. Amresh Kumar Nayak
Central Rice Research Institute, Cuttack, Odisha-753 006
23. Dr. Rajender Kumar Yadav
Central Soil Salinity Research Institute, Zarifa Farm, Kachhwa Road, Karnal, Haryana-132 001
24. Dr. M. Madhu
Indian Institute of Soil & Water Conservation, 218, Kaulagarh Road, Dehradun, Uttarakhand 248 195
25. Dr. Maganti Sheshu Madhav
National Institute for Research on Commercial Agriculture (NIRCA), Rajahmundry, Andhra Pradesh–533 105
26. Dr. G. Byju
Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala-695 017
27. Dr. Parveen Kumar
Central Coastal Agricultural Research Institute, Ela, Old Goa, North Goa, Goa-403 402
28. Dr. Anup Das
ICAR Research Complex for Eastern Region, ICAR Parisar, P.O. Bihar Veterinary College, Patna, Bihar-800 014
29. Dr. Vinay Kumar Mishra
ICAR Research Complex for NEH Region Umroi Road, Umiam, Ri-Bhoi, Meghalaya-793 103
30. Dr. Rajendra Parsad
Indian Agricultural Statistics Research Institute, Library Avenue, Pusa Campus, New Delhi-110 0012
31. Dr. Pankaj Kaushal
Indian Grassland & Fodder Research Institute, Pahuj Dam, Gwalior Road, Jhansi, Uttar Pradesh-284 003
32. Dr. Tusar Kanti Behera
Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bengaluru, Karnataka-560 089
33. Dr. Girish Prasad Dixit
Indian Institute of Pulses Research, Kanpur, Uttar Pradesh-208 024
34. Dr. Siba Prasad Datta
Indian Institute of Soil Sciences, Nabi Bagh, Berasia Road, Bhopal, Madhya Pradesh-462 038
35. Dr. R Dinesh
Indian Institute of Spices Research, Marikunnu P.O., Kozhikode, Kerala-673 012
36. Dr. Rasappa Viswanathan
Indian Sugarcane Research Institute (ISRI), Rai Bareilly Road, P.O. Dilkusha, Lucknow, Uttar Pradesh-226 002

37. Dr. Abhijit Kar
National Institute of Secondary Agriculture, Namkum, Ranchi, Jharkhand-834 010
38. Dr. Nagender Rai (Acting)
Indian Institute of Vegetable Research, PB No. 01, PO Jakhini, Shahanshapur, Varanasi, Uttar Pradesh-221 005
39. Dr. P. Govindaraj
Sugarcane Breeding Institute, Coimbatore, Tamil Nadu-641 007
40. Dr. Lakshmi Kant
Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand-263 601
41. Dr. Gouranga Kar
Central Research Institute for Jute & Allied Fibres, Barrackpore, Kolkata, West Bengal-700120
42. Dr. Sunil Kumar
Indian Institute of Farming System Research, Modipuram, Meerut, Uttar Pradesh-250 110
43. Dr. Kancherla Suresh
Indian Institute of Oil Palm Research, Pedavegi, West Godavari, Andhra Pradesh-534 450
44. Dr. Ravi Kumar Mathur
Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad, Telangana-500 030
45. Dr. Raman Meenakshi Sundaram
Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana-500 030
46. Dr. Ratan Tiwari
Indian Institute for Wheat & Barley Research
P. Box No. 158, Agrasain Marg, Karnal, Haryana-132 001
47. Dr. Arjamadutta Sarangi
Indian Institute of Water Management, Opposite Rail Vihar, Chandersekharpur, Bhubaneshwar, Odisha-751023
48. Dr. Mridula Devi
Central Institute for Women in Agriculture, Plot No.50, Mauza-Jokalandi, P.O. Baramunda, Bhubaneswar, Odisha-751 003
49. Dr. Ayyandar Arunachalam
Central Agro-forestry Research Institute, Near Pahuj Dam, Jhansi, Uttar Pradesh-284 003
50. Dr. Dilip Kumar Ghosh
Central Citrus Research Institute, P.B. No. 464, Shankar Nagar P.O., Amravati Road, Nagpur, Maharashtra-440 010
51. Dr. Pratap Singh Birthal
National Institute of Agricultural Economics & Policy Research, P.B. No. 11305, DPS Marg, Pusa, New Delhi-110 012
52. Dr. Sanjay Kumar
Indian Institute of Seed Science and Technology P.B. No. 11, Kusmaur, P.O. Kaithauli, Mau Nath Bhanjan, Uttar Pradesh-275 101
53. Dr. (Mrs.) Tara Satyavathi Chellapilla
Indian Institute of Shree Anna (Millets) Research, Rajendranagar, Hyderabad, Telangana-500 030
54. Dr. Kunwar Harendra Singh
National Soybean Research Institute, Khandwa Road, Indore, Madhya Pradesh-452 017
55. Dr. Ramcharan Bhattacharya
ICAR-National Institute for Plant Biotechnology, LBS Centre, Pusa Campus, New Delhi-110 012
56. Dr. Mukesh Sehgal
National Research Institute for Integrated Pest Management, LBS Building, New Delhi-110 012
57. Dr. Sushil Kumar Purbey (Acting)
Mahatma Gandhi Integrated Farming Research Institute, Piprakothi, Motihari, East Champaran, Bihar-845 429
58. Dr. Ashok Kumar Tiwari
Central Avian Research Institute
Izatnagar, Bareilly, Uttar Pradesh-243 122
59. Dr. Tirtha Kumar Datta
Central Institute for Research on Buffaloes, Sirsa Road, Hisar, Haryana–125 001
60. Dr. Manish Kumar Chatli
Central Institute of Research on Goats, Makhdoom, Mathura, Uttar Pradesh-281 122
61. Dr. Basant Kumar Das
Central Inland Fisheries Research Institute, Barrackpore, West Bengal-700 120
62. Dr. Kuldeep Kumar Lal
Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, Raja Annamalai Puram, Chennai, Tamil Nadu-600 028
63. Dr. George Ninan
Central Institute of Fisheries Technology, Willingdon Island, Matsyapuri P.O., Kochi, Kerala-682 029
64. Dr. Pramoda Kumar Sahoo
Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneshwar, Khurda, Odisha-751 002
65. Dr. Grinson George
Central Marine Fisheries Research Institute, P.B. No. 1603, Ernakulam North P.O., Kochi, Kerala-682 018
66. Dr. Arun Kumar
Central Sheep & Wool Research Institute, Avikanagar, Tonk, Rajasthan-304 501
67. Dr. Artabandhu Sahoo
National Institute of Animal Nutrition & Physiology, Adugodi, Bengaluru, Karnataka-560 030
68. Dr. Aniket Sanyal
National Institute of High Security Animal Diseases, Anand Nagar, Bhopal, Madhya Pradesh-462 021
69. Dr. Ashok Kumar Mohanty
Central Institute for Research on Cattle, P.B. No. 17, Grass Farm Road, Meerut Cantt, Uttar Pradesh-250 001
70. Dr. Hanuman Sahay Jat
Indian Institute of Maize Research, PAU Campus, Punjab-141 004
71. Dr. Sukhadeo Baliram Barbuddhe
National Meat Research Institute, Chengicherla, P.B. No. 19, Uppal PO, Hyderabad, Telangana-500 039
72. Dr. Baldev Raj Gulati
National Institute of Veterinary Epidemiology and Disease Informatics, H.A. Farm Post, Hebbal, Bengaluru, Karnataka-560 024
73. Dr. Sandip Kumar Bera
Indian Institute of Groundnut Research, Post Box No.5, Ivnagar Road, Junagadh, Gujarat-362 001
74. Dr. Pramod Kumar Rai
Indian Institute of Rapeseed and Mustard Research, Sewar, Bharatpur, Rajasthan-321 303

APPENDIX 6

NATIONAL BUREAUX AND THEIR DIRECTORS

1. Dr. Satya Nand Sushil
   National Bureau of Agricultural Insect Resources, P.B. No. 2491, H.A. Farm Post, Bengaluru, Karnataka-560 024

2. Dr. Alok Kumar Srivastava (Acting)
   National Bureau of Agriculturally-Important Micro-organisms, P.B. No. 6, Kusmaur, Maunath Bhanjan, Uttar Pradesh-275 101

3. Dr. Gyanendra Pratap Singh
   National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110 012

4. Dr. Nitin Gorakh Patil
   National Bureau of Soil Survey and Land Use Planning, Shankar Nagar, P.O. Amravati Road, Nagpur, Maharashtra-440 010

5. Dr. Bishnu Prasad Mishra
   National Bureau of Animal Genetic Resources, P.B. No. 129, G.T. Road Bye Pass, Karnal, Haryana-132 001

6. Dr. Uttam Kumar Sarkar
   National Bureau of Fish Genetic Resources, Canal Ring Road, P.O. Dilkusha, Lucknow, Uttar Pradesh-226 002

APPENDIX 7

DIRECTORATES AND AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTES AND THEIR DIRECTORS

1. Dr. Anuradha Agrawal,
Project Director (DKMA),
Directorate of Knowledge Management in Agriculture,
Krishi Anusandhan Bhawan-I, Pusa, New Delhi-110 012

2. Dr. Pothula Srinivasa Brahmanand,
Project Director, Water Technology Centre,
IARI Campus, Pusa, New Delhi-110 012

3. Dr. Janki Sharan Mishra
Directorate of Weed Research, Maharajpur, Adhartal,
Jabalpur, Madhya Pradesh-482 004

4. Dr. Jamboor Dinakara Adiga
Directorate of Cashew Research, Darbe, P.O. Puttur,
Dakshina Kannada, Karnataka-574 202

5. Dr. K. V. Prasad
Directorate of Floriculture Research, Zed Corner,
Mundhwa Manjari Road, Pune, Maharashtra-411 036

6. Dr. Manish Das
Directorate of Medicinal & Aromatic Plants Research,
Boriavi, Anand, Gujarat-387 310

7. Dr. Ved Prakash Sharma
Directorate of Mushroom Research, Chambaghat,
Solan, Himachal Pradesh-173 213

8. Dr. Vijay Mahajan
Directorate on Onion & Garlic Research, Rajgurunagar,
Pune, Maharashtra-410 505

9. Dr. Rabindra Prasad Singh
Directorate of Foot and Mouth Disease, Bhubaneshwar,
Odisha-752 050

10. Dr. Rudra Nath Chatterjee
Directorate of Poultry Research, Rajendranagar,
Hyderabad, Andhra Pradesh - 500 030

11. Dr. Pramod Kumar Pandey
Directorate of Coldwater Fisheries Research,
Anusandhan Bhawan, Industrial Area, Bhimtal,
Uttarakhand-263 136

Agricultural Technology Application Research Institutes

12. Dr. Parvender
Agricultural Technology Application Research Institute,
Zone-I, PAU Campus, Ludhiana, Punjab - 141 004

13. Dr. Amulya Kumar Mohanty
Agricultural Technology Application Research Institute,
Zone-III, TOP, Umroi Road, Barapani, Meghalaya - 793 103

14. Dr. Shantanu Kumar Dubey
Agricultural Technology Application Research Institute,
Zone-IV, G.T. Road, Rawatpura, Near Vikas Bhawan,
Kanpur, Uttar Pradesh - 208 002

15. Dr. Anjani Kumar
Agricultural Technology Application Research Institute,
Zone IV, CPRS Campus P.O, Sahay Nagar, Patna,
Bihar - 801 506

16. Dr. Nagulameera Shaik
Agricultural Technology Application Research Institute,
Zone-V, CRIDA Complex, Santoshnagar, Hyderabad,
Telangana – 500 059

17 Dr. Pradip Dey
ICAR-Agricultural Technology Application Research Institute, Kolkata, Zone V, Bhumi Vihar Complex, Block GB, Sector II, Salt Lake City, Kolkata, West Bengal - 700 097

18. Dr. Jai Prakash Mishra
Agricultural Technology Application Research Institute,
Zone-VI, CAZRI Campus, Jodhpur, Rajasthan - 342 003

19. Dr. Kadirvel Govindasamy
Agricultural Technology Application Research Institute,
Zone VI, Banphool Nagar, Basisthpur, Guwahati,
Assam - 781 006

20. Dr. Shyam Ranjan Kumar Singh
Agricultural Technology Application Research Institute,
Zone-VII, JNKVV Campus, Jabalpur, Madhya Pradesh - 484 002

21. Dr. Subrata Kumar Roy
ICAR-Agricultural Technology Application Research Institute (ATARI), Zone VIII, Pune, Maharashtra

22. Dr. V. Venkatasubramanian
Agricultural Technology Application Research Institute,
Zone-VIII, ICAR Transfer of Technology Project,
MRS HA Farm Post, Hebbal, Bengaluru, Karnataka - 560 030

APPENDIX 8

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

1. Dr. R. Selvarajan
   National Research Centre for Banana, Thogamalai Road, Thayanur Post, Thiruchirapalli, Tamil Nadu–620 102

2. Dr. Kaushik Banerjee
   National Research Centre for Grapes, P.B. No. 3, Manjri Farm Post, Solapur Road, Pune , Maharashtra-412 307

3. Dr. Bikas Das
   National Research Centre for Litchi, Mushahari Farm, Mushahari, Muzaffarpur, Bihar–842 002

4. Dr. Sankar Prasad Das
   National Research Centre for Orchids, Pakyong, Gangtok, Sikkim–737 106

5. Dr. Rajiv Arvind Marathe
   National Research Centre on Pomegranate, NH-65, Solapur-Pune Highway, Kegaon, Solapur, Maharashtra–413 006

6. Dr. Vinay Bhardwaj
   National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan–305 206

7. Dr. S.K. Ghorui (Acting)
   National Research Centre on Camel, Jorbeer, P.B. No. 07 Bikaner, Rajasthan–334 001

8. Dr. Tarun Kumar Bhattacharya
   National Research Centre for Equines, Sirsa Road, Hisar, Haryana –125 001

9. Dr. Girish Patil S.
   National Research Centre for Mithun, Jharnapani, P.O. Medziphema, Nagaland–797 106

10. Dr. Vivek Kumar Gupta
    National Research Centre on Pig, Rani, Guwahati, Assam–781 131

11. Dr. Mihir Sarkar
    National Research Centre on Yak, Dirang, West Kameng, Arunachal Pradesh–790 101

APPENDIX 9

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

AICRPs

1 AICRP on Seed, Mau
2 AICRP on Rice, IIRR, Hyderabad
3 AICRP on Wheat & Barley, IIWBR, Karnal
4 AICRP on Maize, IIMR, Ludhiana
5 AICRP Sorghum and Small Millets, IIMR, Hyderabad
6 AICRP Pearl millet, IIMR Regional Station, Barmer (Rajasthan)
7 AICRP on Forage Crops and Utilization, IGFRI, Jhansi
8 AICRP on Rabi Pulses, IIPR, Kanpur
9 AICRP on Kharif Pulses, IIPR, Kanpur
10 AICRP on Groundnut, Junagarh
11 AICRP on Soybean, Indore
12 AICRP on Rapeseed & Mustard, Bharatpur
13 AICRP on Oilseed, Hyderabad
14 AICRP on Sesame and Niger, Jabalpur
15 AICRP on Sugarcane, Lucknow
16 AICRP on Cotton, Coimbatore
17 AICRP on Bio-control of Crop Pests, NBAIR, Bengaluru
18 AICRP on Nematodes in Agriculture, IARI, New Delhi
19 AICRP - Honeybees and Pollinators, IARI, New Delhi
20 AICRP Fruits (Tropical and Sub Tropical), Bengaluru
21 AICRP Potato, Shimla
22 AICRP Tuber Crops, Tiruvanthapuram
23 AICRP Arid Zone Fruits, Bikaner
24 AICRP Floriculture, Pune
25 AICRP Mushroom, Solan
26 AICRP Vegetables, Varanasi
27 AICRP Palms, Kasargod
28 AICRP on Cashew, Puttur
29 AICRP Spices, Calicut
30 AICRP on Medicinal & Aromatic Plants, Anand
31 AICRP on Micro and Secondary Nutrients & Pollutant Elements in Soils and Plants, Bhopal
32 AICRP on Soil Test Crop Response, Bhopal
33 AICRP on Long Term Fertilizer Experiments, Bhopal
34 AICRP on Management of Saline Water & Associated Salinization in Agriculture
35 AICRP on Irrigation Water Management, Bhubaneshwar
36 AICRP on Dryland Agriculture, Hyderabad
37 AICRP on Agrometeorology, Hyderabad
38 AICRP on Integrated Farming System, Modipuram
39 AICRP on Agroforestry, Jhansi
40 AICRP on Weed Management, Jabalpur
41 AICRP on Farm Implements and Machinery, CIAE, Bhopal
42 AICRP on Energy in Agriculture and Agro-based Industries, CIAE, Bhopal
43 AICRP on Increased Utilization of Animal Energy with Enhanced System Efficiency, CIAE, Bhopal
44 AICRP on Ergonomics and Safety in Agriculture, CIAE, Bhopal
45 AICRP on Plastic Engineering in Agriculture Structures and Environment Management, Ludhiana
46 AICRP on Post Harvest Engineering and Technology, Ludhiana
47 AICRP on Cattle, Meerut
48 AICRP on Poultry, Hyderabad
49 AICRP on Pig, Guwahati
50 AICRP on Goat Improvement, Makhdoom
51 AICRP on Nutritional & Reproduction and Outreach Methane Project, NIANP, Bengaluru
52 AICRP on Women in Agriculture, CIWA, Bhubaneswar

AINPs

1 All India Network Project on Biotech Crops, NIPB, New Delhi
2 All India Coordinated Research Network on Potential Crops, New Delhi
3 All India Network Project on Tobacco, Rajamundry
4 All India Network Project on Jute and Allied Fibres, Barrackpore
5 All India Network Project on Pesticides Residues & Contaminants, IARI, New Delhi
6 All India Network Project on Emerging Pests, New Delhi
7 All India Network Project on Vertebrates, Soil Arthropods and Mite pest Management, NCIPM, New Delhi
8 All India Network Research Project on Onion and Garlic, Pune
9 All India Network Project on Soil Biodiversity - Biofertilizer, Bhopal
10 Network Programme on Organic Farming, Modipuram
11 Network Project on Harvesting, Processing and Value Addition of Natural Resins & Gums, Ranchi
12 Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
13 All India Network Project on One Health approach to Zoonotic Diseases, Izatnagar
14 All India Network Project on Challenging and Emerging Diseases of Animals, Izatnagar
15 All India Network Project on Ethno-veterinary Medicine, Izatnagar
16 All India Network Project on Livestock and Poultry Product Safety, Izatnagar
17 All India Network Project on Diagnostic Imaging for Management of Surgical Conditions in Animals, Izatnagar
18 Network Project on Buffalo Improvement, Hisar
19 Network Project on Animal Genetic Resource, Karnal
20 Network Project on Sheep Improvement, Avikanagar
21 All India Network Project on Mariculture, Kochi
22 All India Network Project on Ornamental Fish Culture, Kochi
23 All India Network Project on Fish Health, Chennai
24 All India Network Project on Antimicrobial Resistance, Lucknow

CRPs

1 CRP on Hybrid Technology, New Delhi
2 CRP on Molecular Breeding, New Delhi
3 CRP on Agrobiodiversity, New Delhi
4 CRP on Biofortification, IIRR, Hyderabad
5 CRP on Conservation Agriculture, Bhopal
6 CRP on Water, Bhubaneshwar
7 CRP on Energy from Agriculture, Bhopal
8 CRP on Engineering Intervention in Precision Farming and Micro irrigation System, Bhopal
9 CRP on Secondary Agriculture, Ludhiana
10 CRP on Nature Fibre, Mumbai
11 CRP on Vaccines and Diagnostics, Izatnagar
12 CRP on Genomics, Lucknow

Others

1 Application of Micro-organisms in Agriculture and Allied Sectors , NBAIM, Mau
2 Network Project on Translational Genomics Crops Plant, NIPB, New Delhi
3 Incentivizing research in agriculture, NRRI, Cuttack
4 Global R&D Hub for millets in India, IIMR, Hyderabad
5 Enhancing climate resilience and ensuring food security with genome editing tool (Crop Science, Horticultural Science, Animal Science, Fisheries Science, Agricultural Engineering)
6 Advanced Research Project on Canines, Izatnagar
7 Outreach Programme of Yak for Ladakh
8 Network Project on Agricultural Bioinformatics and Computational Biology

APPENDIX 10

TOTAL NUMBER OF EMPLOYEES IN THE ICAR AND ITS RESEARCH INSTITUTES, AND NUMBER OF EMPLOYEES OF SCHEDULED CASTES, SCHEDULED TRIBES AND OTHER BACKWARD CLASSES, AND PWD EMPLOYEES

	Total Posts Sanctioned	Total Employees in Position	SC Employees	Percent to Total Employees	ST Employees	Percent to Total Employees	OBC Employees	Percent to Total Employees	PWD Employees	Percent to Total Employees	EWS Employees	Percent to Total Employees
Administrative												
Group-A	587	449	74	16.48	37	8.24	70	15.59	9	2.00	0	0.00
Group-B	3045	1743	261	14.97	130	7.46	322	18.47	39	2.24	23	1.32
Group-C	1236	693	139	20.06	65	9.38	186	26.84	6	0.87	0	0.00
Total	4868	2885	474	51.51	232	25.08	578	60.90	54	5.11	23	1.32
Multi-Tasking Staff												
Total	4889	2757	661	23.98	221	8.02	484	17.56	19	0.69	2	0.07
Technical Cadre												
Category-I	3717	2750	477	17.35	271	9.85	582	21.16	31	1.13	76	2.76
Category-II	2600	1296	193	1.4.89	121	9.34	311	24	18	1.39	0	0
Category-III	721	443	49	11.06	47	10.61	111	25.06	14	3.16	26	5.87
Total	7038	4489	719	16.02	439	9.78	1004	22.37	63	1.40	102	2.27
Scientific Cadre												
Scientist	4451	3589	536	14.93	229	6.38	1097	30.56	28	0.78	0	0
Senior Scientist	1295	810	52	6.41	15	1.85	95	11.72	0	0	0	0
Principal Scientist	665	544	35	6.43	8	1.47	59	10.84	1	0.18	0	0
RMP	175	165	5	3.03	0	0	8	4.84	0	0	0	0
Total	6586	5108	628	12.29	252	4.93	1259	24.65	29	0.57	0	0

APPENDIX 11

LIST OF DISCIPLINE WISE AGRICULTURAL UNIVERSITIES

State	Name of the University	Discipline	YoE
Andhra Paresh	Acharya NG Ranga Agricultural University, Guntur	Agriculture	1964
Assam	Assam Agricultural University, Jorhat	Agriculture	1969
Bihar	Bihar Agricultural University, Sabour, Bhagalpur	Agriculture	2010
Bihar	Dr. R. P. Central Agricultural University, Pusa, Samstipur, Bihar	Agriculture	1970
Chattishgharh	Indira Gandhi Krishi Viswa Vidhyalaya, Raipur	Agriculture	1987
Delhi	Indian Agricultural Research Institute, New Delhi	Agriculture	1958
Gujarat	Anand Agricultural University, Anand	Agriculture	2004
Gujarat	Junagadh Agricultural University, Junagadh	Agriculture	1973
Gujarat	Sardar Krushinagar Dantiwada Agricultural University, Dantiwada	Agriculture	2004
Gujarat	Gujarat Natural Farming Sciences University,	Agriculture	2017
Gujarat	Navsari Agricultural University, Navsari	Agriculture	2004
Haryana	Chaudhary Charan Singh Haryana Agricultural University, Hisar	Agriculture	1970
Himachal Pradesh	Ch. Sarwan Kumar Himachal Pradesh Krishi Viswavidyalaya, Palampur	Agriculture	1975
Jammu & Kashmir	Sher-e-Kashmir University of Agricultural Science & Technology, Jammu	Agriculture	1999
Jammu & Kashmir	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar	Agriculture	1982
Jharkhand	Birsa Agricultural University, Ranchi	Agriculture	1981
Karnataka	University of Agricultural Sciences, Bengaluru	Agriculture	1965
Karnataka	University of Agricultural Sciences, Raichur	Agriculture	2008
Karnataka	University of Agricultural Sciences, Dharwad	Agriculture	1986
Karnataka	University of Agriculture & Horticulture Sciences, Shimoga	Agriculture	2012
Kerala	Kerala Agricultural University, Thrissur	Agriculture	1972
Madhya Pradesh	Jawaharlal Nehru Krishi Viswa Vidyalaya, Jabalpur	Agriculture	1964
Madhya Pradesh	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior	Agriculture	2008
Maharashtra	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani	Agriculture	1972
Maharashtra	Mahatam, Phule Krishi Vidyapeeth, Rahuri	Agriculture	1965
Maharashtra	Dr. Punjabrao Deshmukh Krishi Viswa Vidyapeeth, Akola	Agriculture	1969
Maharashtra	Dr. Balaesahib Sawant Kokan Krishi Vidyapeeth, Dapoli	Agriculture	1972
Manipur	Central Agricultural University, Imphal	Agriculture	1993
Nagaland	Nagaland University, Medziphema	Agriculture	1994
Odisha	Odisha University of Agricultural & Technology, Bhubaneswar	Agriculture	1962
Punjab	Punjab Agricultural University, Ludhiana	Agriculture	1962
Rajasthan	Agriculture University, Kota	Agriculture	2013
Rajasthan	Maharana Pratap University of Agriculture & Technology, Udaipur	Agriculture	1999
Rajasthan	Swami Keshwanand Rajasthan Agricultural University, Bikaner	Agriculture	1987
Rajasthan	SKN Agriculture University, Jobner	Agriculture	2013
Rajasthan	Agriculture University, Jodhpur	Agriculture	2013
Tamil Nadu	Tamil Nadu Agricultural University, Coimbatore	Agriculture	1971
Telangana	Professor Jayashankar Telangana State Agricultural University, Hyderabad	Agriculture	2014
Uttar Pradesh	Chandra Shekhar Azad University of Agricultural & Technology, Kanpur	Agriculture	1975
Uttar Pradesh	Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut	Agriculture	2000
Uttar Pradesh	Rani Laxmi Bai Central Agricultural University, Jhansi	Agriculture	2014

State	Name of the University	Discipline	YoE
Uttar Pradesh	Narendra Deva University of Agriculture & Technology, Faizabad	Agriculture	1974
Uttar Pradesh	Banda University of Agriculture and Technology, Banda	Agriculture	2011
Uttar Pradesh	Aligarh Muslim University, Aligarh	Agriculture	1920
Uttar Pradesh	Banaras Hindu University, Varanasi	Agriculture	1931
Uttarakhand	G.B. Pant University of Agriculture & Technology, Pantnagar	Agriculture	1960
West Bengal	Uttar Banga Krishi Viswavidhyalaya, Cooch Behar	Agriculture	2001
West Bengal	Bidhan Chandra Krishi Viswa Vidhyalaya, Mohanpur	Agriculture	1974
West Bengal	Vishva Bharti, Sriniketan	Agriculture	1951
Andhra Paresh	Sri Venkateswara Veterinary University, Tirupati	Veterinary	2005
Bihar	Bihar Animal Sciences University, Patna	Veterinary	2016
Chattishgharh	Chhattisgarh Kamdhenu Visvavidyalaya, Durg	Veterinary	2012
Gujarat	Kamdhenu University, Amreli	Veterinary	2013
Haryana	Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar	Veterinary	2010
Haryana	National Dairy Research Institute, Karnal	Veterinary & Dairy	1989
Karnataka	Karnataka Veterinary, Animal and Fisheries Sciences, Bidar	Veterinary	2004
Kerala	Kerala Veterinary and Animal Sciences University, Pookode, Wayanand, Kerala	Veterinary	2010
Madhya Pradesh	Nanaji Deshmukh Pashu Chikitsa Visva Vidyalaya, Jabalpur	Veterinary	2009
Maharashtra	Maharashtra Animal & Fishery Sciences University, Nagpur	Veterinary	2000
Punjab	Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana	Veterinary	2005
Rajasthan	Rajasthan University of Veterinary & Animal Sciences, Bikaner	Veterinary	2010
Tamil Nadu	Tamil Nadu Veterinary & Animal Sciences University, Chennai	Veterinary	1989
Telangana	Sri P V Narsimha Rao Telangana Veterinary University, Hyderabad	Veterinary	2014
Uttar Pradesh	U.P. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vishwa Vidhyalaya Evem Go Anusandhan Sansthan, Mathura	Veterinary	2001
Uttar Pradesh	Indian Veterinary Research Institute, Bareilly	Veterinary	1983
West Bengal	West Bengal University of Animal & Fishery Sciences, Kolkata	Veterinary	1995
Andhra Pradesh	Andhra Pradesh Fisheries University, Narasapur, West Godavari	Fisheries	2020
Kerala	Kerala University of Fisheries and Ocean Studies, Panangad, Kochi	Fisheries	2011
Maharashtra	Central Institute of Fisheries Education, Mumbai	Fisheries	1989
Tamil Nadu	Tamil Nadu Dr J Jayalalithaa Fisheries University , Nagapattinam	Fisheries	2012
Andhra Paresh	Dr. YSR Horticulture University Venkataramannagudem	Horticulture	2007
Chattishgharh	Mahatma Gandhi University of Horticulture & Forestry, Durg	Horticulture & Forestry	2020
Haryana	Haryana State University of Horticultural Sciences, Karnal	Horticulture	2016
Himachal Pradesh	Dr. Yaswant Singh Parmar University of Horticulture & Forestry, Solan	Horticulture & Forestry	1985
Karnataka	University of Horticulture Science, Bagalkot	Horticulture	2008
Telangana	Sri Konda Laxman Telangana State Horticultural, University, Hyderabad	Horticulture	2014
Uttarakhand	VCSG Uttarakhand University of Horticulture & Forestry, Bharsar	Horticulture	2011

Disciplines	Number of Universities
Agriculture	48
Horticulture	7
Veterinary and Animal Sciences	17
Fisheries	4

Acronyms

ABI : Agri-business Incubation
ACR : Agro climatic region
AER : Agro ecological Region
AgIn : Agri-Innovate India Limited
AICRP : All India Coordinated Research Project
AI : Artificial Intelligence
ANN : Artificial neural network
APIS : Application Programming Interfaces
APR : Adult plant resistance
ARYA : Attracting and Retaining Youth in Agriculture
ASIS : Abiotic Stress Information System
ATICs : Agricultural Technology Information Centres
AQPs : Aquaporins
AWC : Available water capacity
BBF : Broad Bed Furrow
BEP : Break-even point
BLB : Bacterial Leaf Blight
BMC : Bulk Milk Chiller
BPH : Brown plant-hopper
CA : Conservation Agriculture
CAAST : Centres for Advanced Agricultural Sciences and Technology
CAFT : Centre for Advanced Faculty Training
CAM : Crassulacean Acid Metabolism
CAUs : Central Agricultural Universities
CCARI : Central Coastal Agricultural Research Institute
CELISA : Competitiveenzyme-linked immunosorbent assay
CFLDs : Cluster Frontline Demonstrations
CIAE : Central Institute of Agricultural Engineering
CIWA : Central Institute for Women in Agriculture
CRI : Crown Root Initiation
CSAT : Climate Smart Agriculture Technologies
CSISA : Cereal Systems Initiatives for South Asia
DARE : Department of Agricultural Research and Education
DBT : Direct Benefit Transfer
DSp : Diagnostic specificity
DST : Drought and Salt Tolerance
DUs : Deemed-to-be-Universities
e-HRMS : Electronic Human Resource Management System
e-IAS : Eco-Friendly Irrigation Alert System
FAW : Fall armyworm
FF : Farmers First
FLDs : Frontline Demonstrations
FMD : Foot and mouth disease
FPOs : Farmer Producer Organizations
FVMS : Foreign Visit Management System
GBS : Genotyping by Sequencing
GM : Grey mildew
GHG : Greenhouse Gas
GRB : Gender Responsive Budgeting
GWAS : Genome-wide association study
GWP : Global Warming Potential
ICT : Information and Communication Technology
IDA : International Depository Authority
IFS : Integrated Farming System
IG : Innovation Grants
IGP : Indo-Gangetic Plain
IMTA : Integrated multi-trophic aquaculture
INSA : Indian National Soil Archive
IOFS : Integrated organic farming system
IoT : Internet of Things
IP : Intellectual Property
IPO : Indian Patent Office
IISS : Indian Institute of Soil Science
Kisan Sarathi: System of Agri-information Resources Auto Transmission and Technology Hub Interface
KSHAMTA : Knowledge Systems and Homestead Agriculture Management in Tribal Areas
KVKs : Krishi Vigyan Kendras
LABYV : Luffa Aphid-borne Yellow Virus
LAMP : Loop-mediated Isothermal Amplification
LGP : Length of Growing Period
M&AP : Medicinal and Aromatic Plants
MAS : Market assisted selection

MLB : Maydis Leaf Blight
MGMG : Mera Gaon Mera Gaurav
MLIFS : Multilayer integrated farming system
MoA : Memorandum of Agreement
MSSP : Mega Sheep Seed Project
MTAS : Marker Trait Associations
MYMV : Mungbean Yellow Mosaic Virus
NAARM : National Academy of Agricultural Research Management
NAE : Niche Area of Excellence
NAIMCC : National Agriculturally Important Microbial Culture Collection
NARES : National Agricultural Research and Education System
NARI : Nutri-sensitive Agricultural Resources and Innovations
NARES : National Agricultural Research and Education System
NASF : National Agricultural Science Fund
NBAIM : National Bureau of Agriculturally Important Microorganisms
NBAIR : National Bureau of Agricultural Insect Resources
NBFGR : National Bureau of Fish Genetic Resources
NCBI : National Centre for Biotechnology Information
NEH : North Eastern Hill
NEP : New Education Policy
NFSM : National Food Security Mission
NGRR : National Genomic Resource Repository
NHCP : National Herbarium of Cultivated Plants
NIAP : National Institute of Agricultural Economics and Policy Research
NICRA : National Innovations in Climate Resilient Agriculture
NINFET : National Institute of Natural Fibre Engineering and Technology
NTS : National Talent Scholarship
NUE : Nitrogen Use Efficiency
OPU-IVF-ET: Ovum pick up and *in-vitro* fertilization-embryo transfer
PBW : Pink bollworm
PDMC : Pere Drop More Crop
PPV&FRA : Protection of Plant Varieties and Farmers' Rights Authority
QTL : Quantitative trait loci
RDF : Recommended dose of fertilizer
RILs : Recombinant inbred lines
RSM : Response surface methodology
SAUs : State Agricultural Universities
SCNT : Somatic Cell Nuclear Transfer
SDGs : Sustainable Development Goals
SHG : Self Help Group
SMDs : Subject Matter Division
SPARROW : Smart Performance Appraisal Report Recording Window
SSDF : Sub-surface Drip Fertigation
SOC : Soil Organic Carbon
Student READY : Rural Entrepreneurship Awareness Development Yojana
TL : Truthfully labelled
TLB : Turcicum leaf blight
TPS : True Potato Seed
TSP : Tribal Sub-Plan
UGV : Unmanned Robotic Ground Vehicle
VOCs : Volatile Organic Compounds
VRT : Variable Rate Technology
WUE : Water Use Efficiency
ZT : Zero tillage

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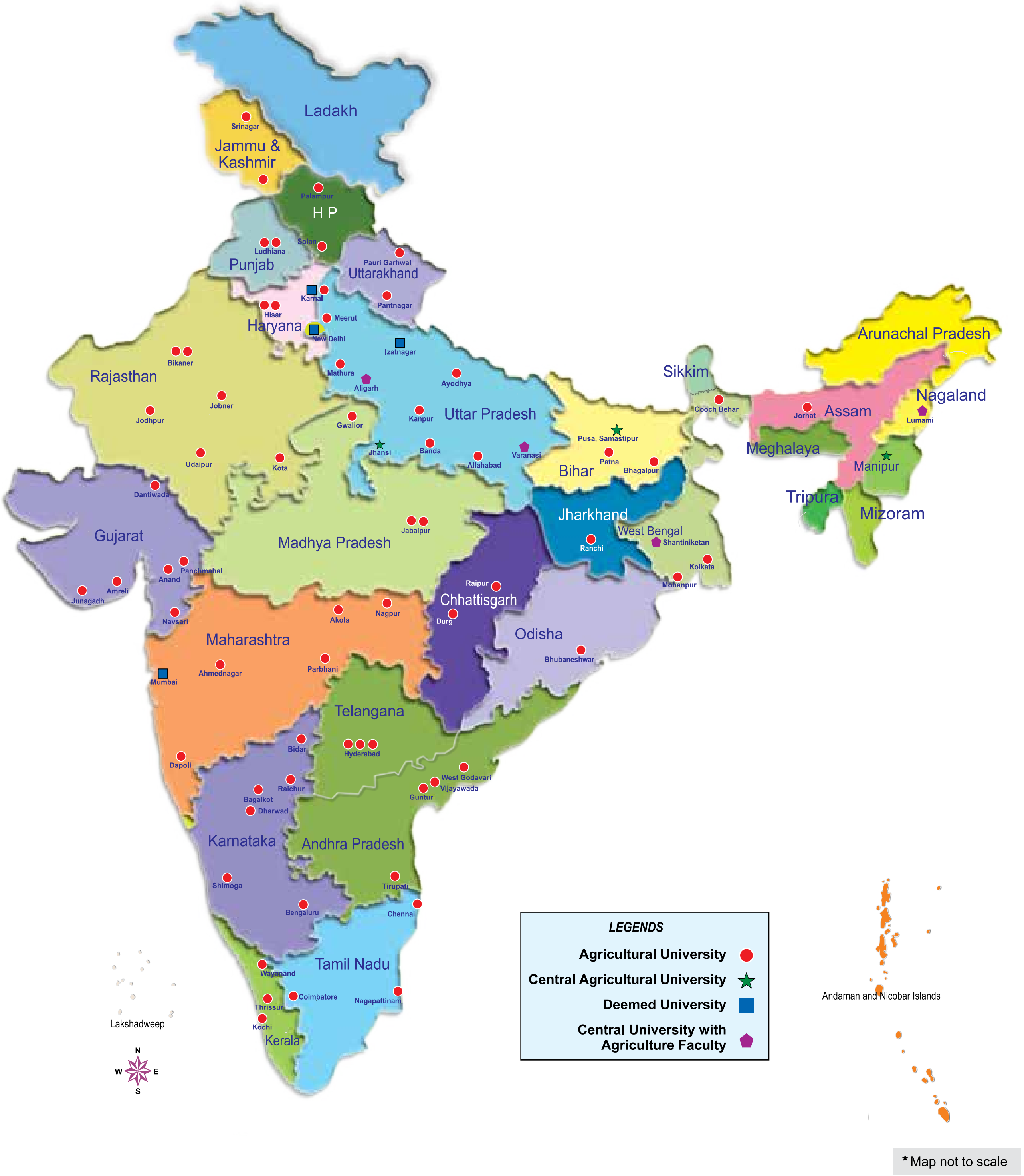

• 66 State Agricultural Universities (SAUs) • 3 Central Agricultural Universities • 4 Deemed Universities
• 4 Central Universities having Faculty of Agriculture

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