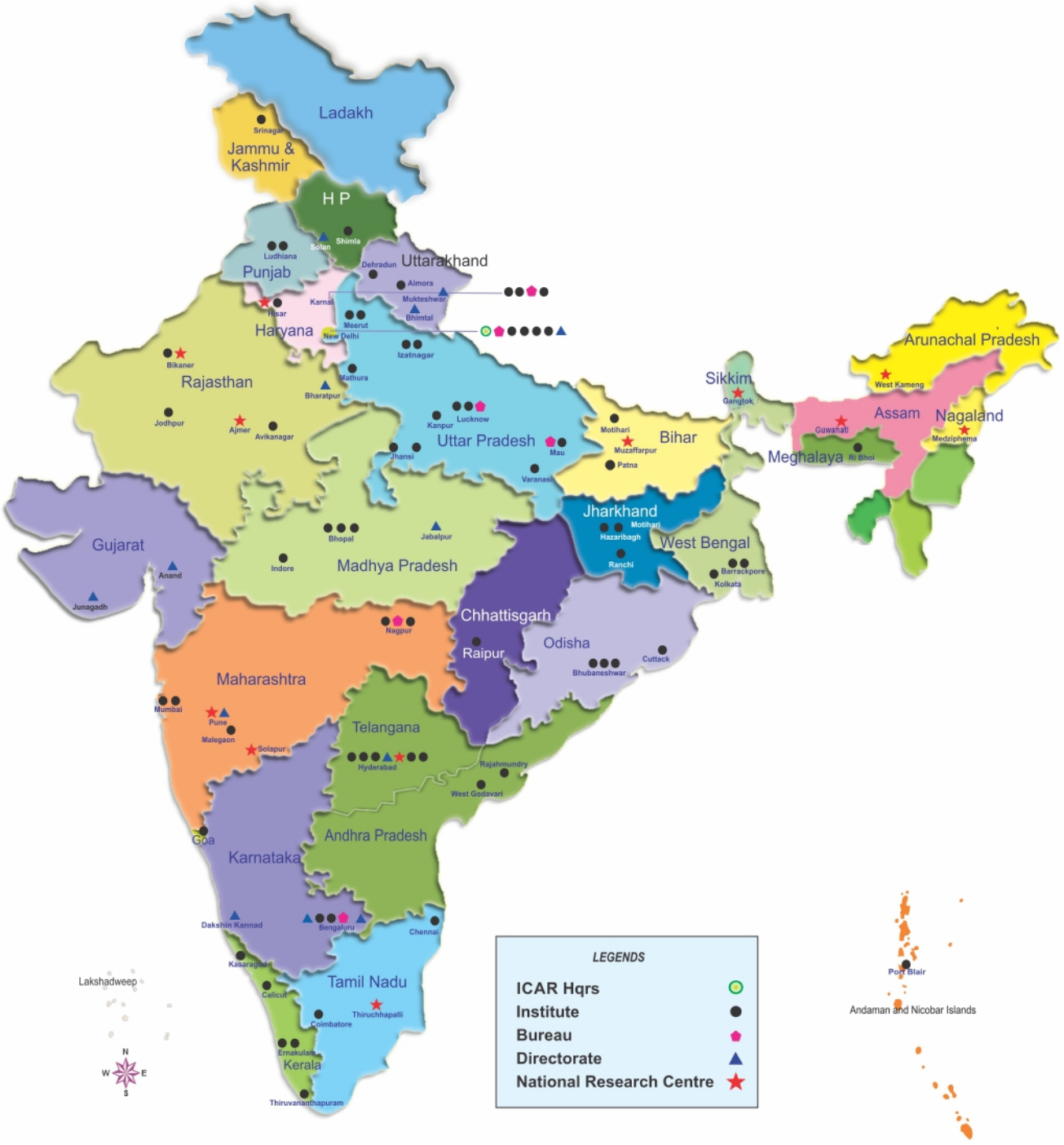
ANNUAL REPORT

2022-23

Indian Council of Agricultural Research
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India
New Delhi

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates and National Research Centres



*Map not to the scale

• 72 Research Institutes • 6 Bureaux • 12 Directorates • 12 National Research Centres

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भाकृअनुप
ICAR
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Foreword

भारतीय कृषि अनुसंधान परिषद द्वारा किसानों, उत्पादकों और उपभोक्ताओं तक पहुंच स्थापित करने के लिए अभूतपूर्व खोज एवं प्रौद्योगिकियां सुनिश्चित की जाती हैं। परिषद द्वारा आत्मनिर्भर कृषि तथा ग्रामीण समृद्धि को सुनिश्चित करने की दिशा में अपने देशव्यापी कृषि अनुसंधान तंत्र के माध्यम से निरंतर कार्य किए जा रहे हैं। इस क्रम में कृषि को अधिक प्रभावी एवं प्रतिस्पर्धी बनाने, प्राकृतिक संसाधनों एवं पर्यावरण को टिकाऊ बनाने, राष्ट्र की खाद्य आपूर्ति सुरक्षा को बढ़ाने एवं पोषण स्थिति में सुधार लाने हेतु विभिन्न शैक्षणिक एवं वैज्ञानिक संगठनों, उद्योग जगत, समस्त सरकारी एजेंसियों के साथ समन्वयन करना भी परिषद के कार्यक्षेत्र में शामिल है। भारत में खाद्य फसलों के उत्पादन को बढ़ाने की दिशा में भाकृअनुप द्वारा राष्ट्रीय कृषि अनुसंधान प्रणाली का नेतृत्व किया जाता है जिसके द्वारा स्थान विशिष्ट नवीन उच्च उपजशील एवं संकर किस्मों और साथ ही खाद्य एवं बागवानी फसलों की उत्पादन एवं संरक्षण प्रौद्योगिकियों का विकास किया जा रहा है।

कृषि वैज्ञानिकों एवं किसानों की मेहनत का ही नतीजा है कि खाद्यान्न के क्षेत्र में भारत, वर्ष 2021–22 में 315.7 मिलियन टन के रिकॉर्ड उत्पादन के उच्चतम स्तर तक पहुंच गया है और तिलहन उत्पादन भी 4 प्रतिशत से भी अधिक बढ़कर 37.7 मिलियन टन प्राप्त हुआ है। पिछले वर्ष में 405.39 मिलियन टन के गन्ना उत्पादन की तुलना में इस वर्ष रिकॉर्ड 431.8 मिलियन टन उत्पादन का अनुमान है। वर्ष 2022–23 के लिए सरकार ने 328 मिलियन टन का खाद्यान्न उत्पादन लक्ष्य निर्धारित किया है जो कि पिछले वर्ष की तुलना में 4 प्रतिशत अधिक है। भावी रणनीतियों में अंतर फसलचक्र, फसल विविधीकरण के माध्यम से कृषि रकबे को बढ़ाना और उच्च उपजशील किस्मों को अपनाकर उत्पादकता में अभिवृद्धि, कम उपज वाले क्षेत्रों में उपयुक्त सस्यविज्ञान रीतियों को अपनाना, अपशिष्ट नमी का उपयोग, अगेती बुआई एवं रबी फसलों के लिए जीवन रक्षक सिंचाई करना शामिल होगा ताकि खाद्य सुरक्षा सुनिश्चित करने के लिए निर्धारित लक्ष्य प्राप्त किया जा सके।

वर्ष 2021–22 के दौरान, कुल 467 किस्मों/संकर किस्मों, जिनमें विशेष गुणों वाली 35 किस्में शामिल हैं (मार्कर सहायतार्थ चयन के माध्यम से विकसित 23 किस्में एवं 12 जैव प्रबलित किस्में), को अधिसूचित कर व्यावसायिक खेती के लिए जारी किया गया। सभी श्रेणियों में कुल गुणवत्ता बीज उत्पादन 3.49 लाख क्विंटल रहा जबकि इसके लिए 3.12 लाख क्विंटल का लक्ष्य रखा गया था। बीज उत्पादन में खेत फसलों का 1 लाख क्विंटल आधारीय बीज, 1.13 लाख क्विंटल प्रमाणित बीज, 86,745 क्विंटल विश्वसनीय लेबल्ड बीज और 48715 क्विंटल रोपण सामग्री शामिल थीं। इसके अलावा, 234.5 लाख रोपण सामग्री और 5.4 लाख ऊतक सवंर्द्धित पादपकों का उत्पादन किया गया जबकि इसके लिए क्रमशः 174.3 लाख एवं 4.7 लाख का लक्ष्य रखा गया था। बागवानी फसलों की कुल 122 किस्मों को भारत की विभिन्न कृषि जलवायु परिस्थितियों में खेती करने के लिए अधिसूचित किया गया। इन किस्मों में फलदार फसलें (15), रोपण फसलें (1), सब्जी फसलें (97), आलू एवं उष्णकटिबंधीय कंदीय फसलें (2) तथा मसाला फसलें (7) शामिल थीं। इन्हें देश के विभिन्न कृषि जलवायु क्षेत्रों में खेती के लिए अधिसूचित कर जारी किया गया। निकोबारी चूजा पक्षियों में CRISPR/Cas द्वारा इन्हीबिन अल्फा जीन का सम्पादन किया गया। कंट्रोल पक्षियों की तुलना में जीन सम्पादित पक्षियों में 72 सप्ताह की आयु अवस्था तक अण्डा उत्पादन में उल्लेखनीय रूप से 103.9 प्रतिशत तक की वृद्धि दर्ज की गई (261 बनाम 128 अण्डे)। जीन सम्पादित पक्षियों में अण्डा गुणवत्ता (हॉग इकाई एवं जर्दी रंग सूचकांक) बेहतर था और पुनर्जनन हार्मोन्स के सीरम स्तर कहीं उच्चतर थे। भेड़ सुधार पर नेटवर्क परियोजना (NWPSI) का उद्देश्य बेहतर वृद्धि और ऊन उत्पादन के लिए चयन के माध्यम से स्वदेशी भेड़ नस्लों का आनुवंशिक मूल्यांकन करना तथा निरन्तर सुधार करना है। किसानों के यहां पल रहे भेड़ झुण्ड का आनुवंशिक सुधार करने के प्रयोजन से किसानों को विभिन्न नस्लों की कुल 425 नर तथा 142 मादा भेड़ें बेची गईं।

कृषि विज्ञान केन्द्रों (KVKs) का अधिदेश देशभर में विभिन्न कृषि परिस्थितियों के तहत प्रौद्योगिकियों के प्रयोग हेतु इनका मूल्यांकन व प्रदर्शन करना तथा किसानों में क्षमता निर्माण का विकास करना है। रिपोर्टाधीन वर्ष के दौरान, सात नए कृषि विज्ञान केन्द्र स्थापित किए गए जिनसे अब देश में कृषि विज्ञान केन्द्रों की कुल संख्या बढ़कर 732 हो गई है। आउटरीच के लिए प्रयोगशाला से खेत तक चलाई गईं गतिविधियों के अलावा अनेक महत्वपूर्ण कार्यक्रम चलाए गए जिनमें शामिल हैं : फार्मर फर्स्ट, कृषि में युवाओं को आकर्षित करना एवं बनाए रखना (ARYA), दलहन एवं तिलहन का क्लस्टर अग्रिम पंक्ति प्रदर्शन, दक्षिण एशिया के लिए अनाज प्रणाली पहल (CSISA), जलवायु अनुकूल कृषि में राष्ट्रीय नवोन्मेष (NICRA), दलहन बीज हब, मेरा गांव – मेरा गौरव तथा सरकारी योजनाओं पर जागरूकता सृजन आदि। इन योजनाओं अथवा कार्यक्रमों को कृषि में युवाओं को शामिल करने, दलहन एवं तिलहन के उत्पादन में आत्मनिर्भरता लाने, टिकाऊ कृषि आदि की विभिन्न चुनौतियों का समाधान करने हेतु चलाया गया।

कृषि में युवाओं को आकर्षित करना एवं बनाए रखना (आर्या) परियोजना को देशभर में स्थित 100 कृषि विज्ञान केन्द्रों में चलाया जा रहा है। वर्ष के दौरान, खुम्ब उत्पादन,

फल व सब्जी प्रसंस्करण इकाइयां, बागवानी नर्सरी, संरक्षित खेती, मत्स्य पालन, पोल्ट्री, बकरी पालन, शूकर पालन, बत्तख पालन, मधुमक्खी पालन तथा वर्मी कम्पोस्टिंग इकाइयों से संबंधित कुल 4,340 उद्यमिता इकाइयां स्थापित की गईं जिनसे कुल 6,610 ग्रामीण युवाओं को लाभ पहुंचा। जलवायु अनुकूल कृषि में राष्ट्रीय नवोन्मेष (NICRA) के प्रौद्योगिकी प्रदर्शन संघटक (TDC) का उद्देश्य भारतीय कृषि की अनुकूलनता को बढ़ाना और भारतीय किसानों को जलवायु प्रतिकूलताओं के प्रति कहीं अधिक अनुकूलनीय बनाना है। इस योजना को नवीनतम जोखिम वर्गीकरण के अनुसार देश के जलवायु की दृष्टि से सर्वाधिक संवेदनशील जिलों में स्थित 151 कृषि विज्ञान केन्द्रों के माध्यम से चलाया जा रहा है। मेरा गांव – मेरा गौरव (MGMG) कार्यक्रम को 127 संस्थानों (भाकृअनुप संस्थान एवं राज्य कृषि विश्वविद्यालय) द्वारा लागू किया और यह कार्य 4,315 वैज्ञानिकों के कुल 1,054 समूहों द्वारा किया जा रहा है। वैज्ञानिकों की टीमों ने 3,680 गांवों को शामिल करते हुए खेत संबंधी कुल 37,982 गतिविधियां चलाईं जैसे कि जागरूकता, प्रदर्शन, प्रशिक्षण एवं बैठकें आदि। किसानों को कुल 27,958 परामर्श संदेश भेजे गए जिनसे 5,05,303 किसान लाभान्वित हुए। उत्पादन और उत्पादकता से आगे बढ़ने; लघु कृषिजोत के किसानों को विशेष अधिकार देने; तथा किसानों व वैज्ञानिकों के मध्य पारस्परिकता को बढ़ाकर अधिकांश किसानों की जटिल, विविध और जोखिम संबंधी चुनौतियों का समाधान करने हेतु भारतीय कृषि अनुसंधान परिषद द्वारा प्रारंभ किया गया फार्मर फर्स्ट एक अग्रणी कार्यक्रम है। सभी माड्यूल में कुल 36,496 प्रदर्शन आयोजित किए गए, 2,649 विस्तार कार्यक्रम चलाए गए, 54,492 पशुओं (पशुधन एवं पोल्ट्री) को लाभ पहुंचाया गया तथा कुल 79,731 किसान परिवारों को शामिल किया गया।

जनजाति कृषि के विकास के लिए भाकृअनुप संस्थानों की जनजाति उप योजना निधि को सुचारू बनाने हेतु जनजाति क्षेत्रों में ज्ञान प्रणाली एवं होमस्टेड कृषि प्रबंधन (KSHAMTA) को प्रारंभ किया गया है। जनजाति क्षेत्रों में ज्ञान प्रणाली एवं होमस्टेड कृषि प्रबंधन (KSHAMTA) को कृषि विज्ञान केन्द्रों के माध्यम से देश के 125 जनजाति बहुल जिलों में लागू किया जा रहा है। आयोजित की गईं गतिविधियों में शामिल हैं : प्रशिक्षण, ओएफटी, अग्रिम पंक्ति प्रदर्शन, विस्तार गतिविधियां, बीज, रोपण सामग्री उत्पादन, आंगुलिक मत्स्य तथा पशुधन स्ट्रेन का उत्पादन, मृदा, जल, पौधों एवं खाद की जांच आदि। कृषि विज्ञान केन्द्रों द्वारा जनजाति उप योजना के तहत किसानों के लिए कुल 4,634 प्रशिक्षण कार्यक्रम आयोजित किए गए जिनमें कुल 1,21,809 किसानों ने भागीदारी की। पोषण संवेदी कृषि, संसाधन एवं नवोन्मेष (NARI) एक अग्रणी कार्यक्रम है जिसे भाकृअनुप द्वारा राष्ट्रीय स्तर पर प्रारंभ किया गया है। बहु क्षेत्रीय कार्रवाई के माध्यम से कुपोषण को समाप्त करने की दिशा में पोषण संवेदी कृषि एक प्रमुख भाग है। पोषण संवेदी कृषि कुपोषण और सूक्ष्म पोषक तत्वों की कमी पर काबू पाने के लिए पोषक तत्वों से भरपूर खाद्य पदार्थ, आहारीय विविधता तथा खाद्य प्रबलीकरण की संभावना को प्रस्तुत करती है। रिपोर्टाधीन वर्ष में कृषि विज्ञान केन्द्रों ने पोषण संवेदी कृषि संसाधन एवं इनोवेशन कार्यक्रम के अंतर्गत ऑन फार्म परीक्षण, प्रौद्योगिकी प्रदर्शन, प्रशिक्षण एवं विभिन्न विस्तार गतिविधियां आयोजित कीं। अग्रिम पंक्ति प्रदर्शनों तथा ओएफटी गतिविधियों के तहत कुल 16,681 पोषण बगीचे स्थापित किए गए जिनसे कुल 30,310 किसान परिवारों को लाभ पहुंचा।

भारतीय कृषि अनुसंधान परिषद द्वारा फसलों, विशेषकर बागवानी फसलों में, तुड़ाई उपरांत नुकसान को कम करने हेतु प्रमुख कृषि उत्पादन क्षेत्रों के निकट प्राथमिक कृषि प्रसंस्करण इकाइयों की स्थापना करने में सहयोग देने पर ध्यान केन्द्रित किया गया। संवर्धित प्राथमिक प्रसंस्करण से मूल्यवर्धन होगा और किसानों को कहीं अधिक लाभ मिलेगा। देश के विभिन्न कृषि पारितंत्र क्षेत्रों के अंतर्गत लघु एवं सीमान्त किसानों की आय में 1.5 से 3.5 लाख रुपये तक वृद्धि करने के प्रयोजन से खेत तथा बागवानी फसलों, कृषि वानिकी, पशुधन, मत्स्य पालन आदि को शामिल करके एकीकृत कृषि प्रणाली मॉडल (1–2 हैक्टर) विकसित किए गए । दोगुनी आय हासिल करने वाले 75,000 किसानों की सफलता गाथाओं को आजादी का अमृत महोत्सव के भाग के तौर पर दस्तावेज के रूप में प्रस्तुत किया गया।

मुझे आशा है कि भाकृअनुप वार्षिक प्रतिवेदन 2022–23 तकनीकी प्रगति और उत्कृष्ट प्रौद्योगिकियों का विकास करने हेतु अनुसंधान को आगे बढ़ाने के कार्य में कृषि से जुड़े विविध हितधारकों के लिए सहायक होगा।

(नरेन्द्र सिंह तोमर)
अध्यक्ष, भाकृअनुप सोसायटी

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Indian Council of Agricultural Research

President, ICAR Society, and Union Minister of Agriculture and Farmers Welfare	:	**Shri Narendra Singh Tomar**
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Vice President, ICAR Society, Union Minister of State for Agriculture and Farmers Welfare	:	**Shri Kailash Choudhary**
Union Minister of State for Agriculture and Farmers Welfare	:	**Shusri Shobha Karandlaje**
Union Minister of State for Fisheries, Animal Husbandry and Dairying	:	**Shri Sanjeev Kumar Balyan**
Secretary, DARE and Director General, ICAR	:	**Dr Himanshu Pathak (From 1 August 2022)** **Dr Trilochan Mohapatra (Till 31 July 2022)**
Additional Secretary, DARE and Secretary, ICAR	:	**Shri Sanjay Garg**
Addition Secretary and Financial Adviser, DARE/ICAR	:	**Mrs Alka Nangia Arora (From 1 June 2022)** **Shri Sanjiv Kumar (Till 31 May 2022)**

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

Indian Council of Agricultural Research (ICAR) has played a central role in realizing the progressive increase in agricultural production with advances in varietal development of field and horticultural crops along with their production and protection technologies; health, nutrition and breed improvement in livestock, poultry and fisheries; innovations in frontline extension and higher agricultural education; and forging international collaborations. However, Indian agriculture is confronted with the challenges of realizing higher production while reducing chemical and water footprints, improving soil health and environment under the global phenomenon of climate change. The future challenges in agriculture are much more formidable, which need quick solutions to address the issues related to sustainability, climate resilience, profitable commercialization, export promotion, import substitution and enhancing competitiveness of our agriculture and allied sector's produce in the global markets.

Indian Council of Agricultural Research, in the recent past, has reoriented its research for developing the technologies for addressing the national priorities and market demands. While enhancing the productivity and production for nation's food security, biofortification for nutrition, abiotic and biotic stress tolerant varieties, production technologies for climate change stresses, high value integrated farming systems for higher farmers' income, specific export potential varieties and products to penetrate the new global destinations are included in the new Research & Development priorities. As we are reimagining Indian agriculture, several long-term of priorities are also set. These include increasing use of renewable energy to 50%, reducing greenhouse gas (GHG) emission intensity by 45% and rehabilitating 26 million ha degraded land. India has several international commitments such as Panchamrit and carbon neutrality, land degradation neutrality, biodiversity conservation, regional agricultural development and SDGs. ICAR has embarked upon working for standardization, validation and demonstration of organic and natural farming including chemical-free technologies through its research institutes and KVK network. Research on genomics and genome editing would be the core research activity the ICAR is pursuing vigorously for technological breakthroughs in the areas and commodities where traditional breeding could not yield desired results. Precision agriculture, digital interface and use of digitally advance technologies, techniques and tools are on the rise in agriculture to facilitate timely monitoring of weather, plant and soil indicators and provide artificial intelligence-based advisories to the farmers. Strategies and protocols for use of drones, sensor-based automation, solar photovoltaic pumping systems, etc. will pave the way for their large-scale adoption by the farmers.The salient achievements of the Council during 2022 -23 are given below.

Crop Improvement: A total of 467 high yielding varieties/hybrids comprising 218 of cereals, 57 of oilseeds, 65 of pulses, 98 of commercial crops, 29 of forage and other crops were released for commercial cultivation. These included 35 special traits varieties (23 MAS and 18 biofortified). A novel QTL (Qlr.nhv-5D.2) on a 5D chromosome was identified for leaf rolling under moisture stress condition in bread wheat. Two new candidate leaf rolling genes, viz. *TaZHD1* and *TaZHD10* belonging to homeodomain-leucine zipper (HD-Zip) class IV family proteins (gene) were identified in the QTL region. Two *C1-Inhibitor (*C1-I) specific breeder-friendly markers (MGU-CI-InDel8 and MGU-C1-SNP1) were developed. MGU-CI-InDel8 and MGU-C1-SNP1 markers predicted presence of C1-I allele with 92.9% and 84.7% accuracy, respectively. A genotyping-by-sequencing (GBS) based genome-wide association study (GWAS) approach using 120 genotypes was employed to dissect the complexity of PUpE (P uptake efficiency) and PUtE (P utilization efficiency) traits at the genetic level in mungbean. This has identified 116 SNPs in 61 protein-coding genes and of these, 16 were found to enhance phosphorous uptake and utilization efficiency in mungbean. The potential of jute flavonoids as an anti-MMP-2 agent was investigated. Flavonoid extract from *Capsularis olitorius* JRO 524 inhibited the breakdown of pro-MMP-2 into active MMP-2, thereby rendering it inactive. A genome-wide survey of cytosine DNA methylation patterns in response to heat stress was conducted to investigate the adaptation of fibre flax cultivars to high temperature stress. Bisulphite sequencing in flax under heat stress conditions identified 85.1-90.5 million methylated DNA loci in CpG/CHG/CHH sequence contexts.

Molecular breeding for the development of rice varieties with inbuilt resistance/tolerance to drought, low soil P, and blast done. A set of genic-SSR markers for winged bean was developed from the publicly available

RNAseq data sets and 58811 unigenes were assembled, and 4,107 perfect SSRs were identified. Effect of Zn deficiency was evaluated in BKS-41 (high seed zinc) and Sadabahar (low seed zinc). Higher shoot length, root length, longer root hair zone, high root hair density, higher relative chlorophyll content and dry weight were observed in BKS-41 as compared to Sadabahar under zinc deficient condition. The study to identify regulatory genes associated with RFOs biosynthesis in peanut (*Arachis hypogaea*) suggested Raffinose Synthase (RS) for the differential accumulation of RFOs. The 4 varieties of faba bean, i.e. *Swarna Suraksha*, *Swarna Safal*, *Swarna Gaurav* and *Pusa Sumeet* were evaluated as a natural source of L-Dopa. Higher amount of L-Dopa was found in immature leaf and flowers. A screening method was designed for amylose estimation in maize kernels. The proposed method is rapid and simple for screening of maize kernels with varied amylose amounts, and gets completed in 1 min. Meta-QTL analysis for fungal disease resistance in maize revealed 128 QTLs associated with resistance against 12 fungal diseases (SLB, NCLB, BLSB, GLS, HS, FSR, FER, GER, AER, PLS, CS, SDM) across the maize genome. Application for an Indian patent (Application No. 202211015547) on rapid differentiation of normal maize from Quality Protein Maize was filed. The developed method requires 5 minutes for differentiating normal maize from QPM, when a milled sample is provided. Genome editing for early flowering and seed size displayed increase in leaf size, stem length and seed weight in edited chickpea lines as compared to their normal control types. Full-length gene sequence of grasspea oxalyl-CoA synthetase and ODAP synthase, enzymes functional in OAP synthesis in grass pea, were identified and submitted to Genbank with accession No. MH469748 and MZ127288, respectively. 2 QTLs/genomic region on chromosome 2 and 8 were mapped for Fusarium wilt resistance in pigeonpea.

CRISPR/Cas technology was utilized to edit the cytokinin oxidase (*OsCKX2)* gene of indica rice cultivar rice controlling the grain number in order to increase the yield of Samba Mahsuri. The genome-edited T0 lines showed 200 to 496 grains/panicle in comparison to ~150 grains/panicle in wild-type or non-edited Samba Mahsuri plants while T1 lines showed desired characters like strong culm and early maturity. To create novel variants for morphological, physiological, and biotic stress tolerance traits, induced mutations were created in the background of Samba Mahsuri (BPT 5204). The mutant lines showing enhanced tolerance to important biotic stresses (YSB, ShB and BLB). Multiple abiotic stress responsive genes were identified using transcriptomics in sugarcane. A chromosome-level reference genome assembly (2.93 Gb; 97.66% Coverage) of Indian Tea (*Camellia assamica* var. Masters cv. TV-1) genome was generated anchoring 99.4% of super-scaffold level assembly into 15 clusters or pseudomolecules by Hi-C data with the size of clusters ranging from 303.18 Mb to 119.95 Mb. A novel abiotic stress responsive gene LOC_ Os06g10210 (*OsCHI2*) isolated from a drought tolerant rice cv. Nagina 22 (N22) which showed upregulation in response to drought stress was identified. miR156 site in *Ideal Plant Architecture 1* (*IPA1*) gene in rice variety, Swarna, was edited. Panicle architecture and spikelets/ panicle improved significantly in edited lines. Presence of Protein Body 1 and 2 under different post-harvest processing conditions of grains of high protein rice CR Dhan 310 was identified. In order to identify the high resistant starch rice, 100 rice lines were analyzed which revealed variation in the range of 0.28% to 2.94% with Gayatri rice line showed the highest resistant starch content of 2.94% over the years (2019 to 2022).

To screen large number of genotypes for vivipary, laboratory method was proved efficient considering the correlation with field observation data, outstanding genotypic difference and convenience of testing. Mutants of BPT 5204 with robust root system architecture, early seedling vigour index, and higher yield under limiting water conditions identified which are suitable for the dry direct seeding under aerobic system of rice cultivation. Genomes of rice restorer line KMR 3 (salinity-sensitive) and its salinity tolerant introgression line IL50-13 were sequenced. Draft genome of yellow stem borer *Scirpophaga incertulas* an agriculturally important pest with 46,057 genes and estimated size of 308 Mb was generated. During 2021-22, breeder seed production in field crops was 1,01,617.5 quintals against the indent of 77,260.1 quintals and total production of quality seed was 3,49,596.6 quintals against the target of 3,12,584.7 quintals. In addition, 234.5 lakh planting material and 5.4 lakh tissue culture plantlets were produced against the targets of 174.3 and 4.7 lakh, respectively.

In horticultural crops, total 122 varieties were notified for cultivation under different agroclimatic conditions. These included 15 varieties of fruits, 1 of plantation crops, 97 of vegetables, 2 of tropical tubers and 7 of spices. The molecular linkage maps of two grape varieties (Carolina Black Rose and Thompson Seedless) developed. Genome assembly of Indian pomegranate cv. Bhagawa was released. Varietal signature for genetic purity of spices were identified and identity of nutmeg varieties IISR Vishwashree, IISR Keralashree and Sindhushree established. Marker free late blight resistant transgenic line KJ 66 of potato identified. A total 1047 activation tagged lines were generated in potato cv. Kufri Jyoti and Kufri Chipsona 1 using activation tagging vector pSKI015. Targeted editing of potato genome was done to develop variety specific True Potato Seed (TPS).

A total of 16 lines of potato with mutation within MiMe genes (StOSD, StREC8 and StSP011) were generated. Molecular identification and diversity of 25 *Pleurotus* mushrooms were investigated. Seven new hybrid strains of *Pleurotus* were developed by mating single spores from *Pleurotus ostreatus* (DMRP 30) and *Pleurotus florida* (DMRP 49). The biological efficiency was maximum recorded for hybrid P18102 (79.00%) in two flushes compared to parents and check on pasteurized wheat straw.

Livestock Improvement: The evidence of selection signatures in the datasets of 284 individuals of Tharparkar cattle along with 11 other indigenous and exotic cattle breeds were demonstrated. Significant candidate genes were identified related to various important traits such as *ADRB2* in Tharparkar; *HERC5, SCC25A48* in Gir; *CA8* in Ongole and *KIAI217* in Sahiwal for milk production; *PARN* in Holstein; *ZBTB20* in Sahiwal; and *APBB1* in Tharparkar for reproduction; *SP110* in Brown Swiss; *HSP90AB1* in Tharparkar and Red Sindhi for thermo-tolerance trait.

The influence of X-linked genes on the sperm functional parameters and field fertility rate in the cattle and Murrah buffalo bulls was studied. The sperm transcriptome studies revealed that the total number and the expression levels of X-linked genes in the mature sperm were very low in both species, and only 23.3% of these genes were commonly expressed between them. The X- linked genes related to embryonic organ development and reproduction were enriched in cattle and buffalo sperm, respectively. The expression levels of X-linked genes *RPL10* and *ZCCHC13* in cattle, and *AKAP4, TSPAN6, RPL10* and *RPS4X* in buffalo were significantly correlated with sperm kinematics. Evidently, the expression level of *RPL10* and *RPS4X* was significantly correlated with the field fertility rate in cattle and buffalo, respectively. Multivariate regression models and receiver operating curve analysis suggested that the expression levels of X-linked genes may be useful in predicting the bull fertility rate.

An egg yolk-free, ready to use, semen extender for cattle and buffalo with higher shelf-life (≥18 months, 4°C) for cryopreservation of buffalo semen was developed for the first time in India. The post-thaw progressive motility of cryopreserved buffalo sperm in the new egg-yolk free semen extender was significantly higher. A farm-to-fork block chain-based buffalo meat traceability system, BuffTrace, has been developed for buffalo meat industry in collaboration with a private company. The system helps in collection of post-slaughter information and retrieval of the traceability information based on the label details.

The complete mitochondrial genome sequences of 88 Indian sheep representing 22 breeds/population were analyzed for the first time to get a comprehensive picture of the maternal diversity in the sheep genetic resources of India. The mitochondrial DNA sequence of all Indian sheep was observed to be 16,617 bp long and contained 37 genes, including 13 protein coding genes, 2 rRNA genes, 22 tRNA genes, and a control region. Network Project on Sheep Improvement (NWPSI) and Mega Sheep Seed Project (MSSP with major objective of improvement of indigenous sheep breeds were initiated.

Concurrent transcriptome and methylome analysis of pig breeds (Mali and Hampshire) with varying muscularity was done to obtain insights into myogenesis. Muscle transcriptome identified 20,226 mRNAs out of which 15,170 were across the samples. Developed economic and nutritionally balanced silage-based pig feed following standard procedure from vegetable wastes adding jaggery (gur) at the rate of 3 kg per 100 kg raw chaffed vegetable waste for suitable anaerobic fermentation in silage bags. A total of 1,934 liquid boar semen doses were produced and supplied for artificial insemination in pigs at the farmers' field and organized farms.

Three climate resilient dual type hardy birds, CARI-Dhawal, CARI-Prabal and CARI-Saloni were developed for efficient egg and meat production.To overcome the antibiotic growth promoters used in poultry feed, CARI-HERBIGROW, a natural product has been developed with the property of antioxidants, immune enhancer, stress reducer and helps chicken to improve overall production. CARI–HERBISTRESSMIN a phytogenic feed additive developed by CARI to reduce effect of heat stress and improve immunity of birds during hot and hot-humid summer. Alternatives for antibiotic growth promoters (AGPs) in feed and alternate protein meal and biofortified maize in poultry diet (black soldier fly (BSF) larva meal) were also developed.

Inhibin alpha gene editing by CRISPR/Cas in Nicobari indigenous chicken led to efficiency of production. The egg production up to 72 weeks of age increased by 203% from 261 eggs in edited birds as compared to 128 egg in control birds. Immunochromatography-based chicken detection kit (ICDK) was developed for the authentication of chicken. Genomic diversity was estimated in Arunachali yak population based on data generated using ddRAD sequencing. Three indices,viz. nucleotide diversity (0.041 in 200 bp windows), effective population size (Ne = 83) and runs of homozygosity (>90% were short and medium length) revealed that the genomic diversity in Arunachali yak breed as of now is optimum.

Fish Improvement: Successful natural spawning of green snapper, *Lethrinus nebulosus* was achieved

in recirculatory aquaculture system (RAS). It is a large tropical marine fish species that grows to 80 cm in length and 8.4 kg in weight. *Lethrinus nebulosus* were collected from wild and developed into functional broodstock in 10 t RAS system. Simple non- invasive breeding and culture protocols have been developed for four indigenous ornamental fishes of the Western Ghat, viz. *Pethia setnai, Pethia nigripinnis, Dawkinsia tambraparniei* and *Dawkinsia arulius*. Similarly, breeding technique were standardized for two endangered species of genus *Dawkinsia*, viz. *Dawkinsia tambraparniei*, the Tambraparniei barb and *Dawkinsia arulius*, the Arulius barb. Two backyard recirculating aquaculture system (RAS) models of rearing tanks size 3 and 7 cubic metrewith production capacity of 30 kg per m^3 were designed, fabricated and validated for small-scale farming of rainbow trout by the farmers of hill states to reduce the initial cost of investment.

Genetic Resources: Total 890 accessions (450 cultivated and 440 wild) including unique landraces of cereals, pulses, oilseeds, vegetables and germplasms of wild edible fruits and wild relatives of the cultivated crops collected through 18 explorations. Under National Gene bank 5,152 accessions of orthodox seed species added for long-term storage resulting into the total of 4,62,923 accessions in its present base collection. In Cryogene bank, 404 accessions of seeds and pollen genomic resources of different crop species were cryopreserved, making the total collection of 12,480 accessions. Total of 41,557 accessions were imported from 37 countries and 14,641 entries from trails/nurseries from CG centres. Imported samples numbering 133,673 were processed for quarantine clearance. One plant quarantine database and two web-based applications were developed. ICAR-NBAIM, the nodal agency for developing DNA fingerprints of microbial cultures to be registered as biopesticides developed fingerprints of more than 487 samples for accurate identity. A total of 26 microbes were accessioned under safe deposition and 72 cultures were sold to academia and companies fetching ₹ 2,91,600 revenue to the institute.

In horticulture, a total of 3,346 accessions were collected and 26 accessions showing unique traits have been registered as novel genetic stock. Five genotypes of longan of fruit size (8.1 – 8.5g/fruit), an oilpalm cross progeny number 483 (599NATP × 33D) promising for more oil to bunch ratio (21.37%) and 175 fungal mushroom accessions identified. A QR coded gene bank exclusively for wild genetic resources of banana established at ICAR-NRC-Banana, Tiruchirappalli. This is the first of its kind in India for conservation of genetic diversity and identify resistant sources to various biotic and abiotic stresses in banana.

In livestock, 10 new breeds of indigenous livestock species, Kathani cattle (Maharashtra), Sanchori cattle (Rajasthan) and Masilum cattle (Meghalaya); Purnathadi buffalo (Maharashtra); Sojat goat (Rajasthan), Karauli goat (Rajasthan) and Gujari goat (Rajasthan); Banda pig (Jharkhand), Manipuri Black pig (Manipur) and Wak Chambil (Meghalaya) were registered making total number of registered indigenous breeds to 212. A total of 44,860 semen doses of 17 native livestock breeds, including nine of cattle (Red Sindhi, Badri, Red Kandhari, Nimari, Deoni, Gaolao, Bhijarpuri, Ghumsari, Khariar) and 8 of goat (Ganjam, Jamnapari, Beetal, Berari, Osmanabadi, Sirohi, Sangamneri and Barbari) were cryopreserved. Also, 1,020 somatic cell vials of 7 native breeds-- Purnea, Mewati, Hariana and Shweta Kapila of cattle, Konkan Kanyal of goat, Doom and Purnea of pig were added for cryopreservation. Presently, National Gene Bank has repository of 61 native breeds/ populations of livestock and poultry in form of semen, and 28 in form of somatic cells. Under the Mission Zero Non-descript AnGR, 22 new populations of native livestock and poultry have been identified. These are being characterized in their respective breeding tracts.

In fisheris, 3 freshwater species *Amblycepsh molaii* from Kawlchaw river, Mizoram; *Pangasius icaria* from Cauvery river, Karnataka; and *Tor sattalensis* from Sattal Lake, Uttarakhand and 5 marine fish/ shrimp *Eptatretus wadgensis*, *Dussumeria modakandai, Ariosomaalbi maculatum, Ariosoma melanospilos* and *Actinimens koyas* were discovered. Canary top wrasse, *Halichoeres leucoxanthus,* previously distributed in Maldives, Myanmar, Chrismas Island (Australia), Thailand and Western Indonesia was found for the first time in Indian waters. For the first time, recorded catch of marine/deep sea fish species like *Aluterus monoceros, Antennarius indicus, Ariomma indica, Diodom hystrix, Labotes surinamensis, Nemipterus randalli, Priacanthus prolixus, Seriolinanigro fasciata,* in Hooghly-Matlah estuary. Indian oil sardine's whole genome assembly is 1.077 GB (31.86 Mb scaffold N50) in size with repeated content of 22.84%. The sequences were deposited in NCBI, GeneBank. The cell lines from rainbow trout heart and snow trout muscles were developed, authenticated and deposited in ICAR-NBFGR National Repository of Fish Cell Lines.

Crop Management: Application ofconsortium of methane utilizing bacteria (MUB) formulation comprising of *Methylobacterium oryzae* MNL7 and *Paenibacillus polymyxa* MaAL 70 through seedling root dip technology and as spray reduced methane emission by 5 to 25% in flooded rice. Rise in temperature by 1.7^{0}C with elevated CO_2 showed an increase in grain yield across two wheat varieties. Elevated CO_2 (ECO_2) with

elevated O_3 (EO_3) alleviated the negative effect of ozone on grain yield. Durum and bread wheat were exposed to leaf compost (LC) and vermicompost (VC) enriched with polyvinyl chloride (PVC) and poly propylene (PP). The microplastics in the farm inputs altered the nutrient availability and uptake. Satellite based crop health indices were developed for whole of India. The spatial layer of active fire points of rice residue burning (October-December) was uploaded on ICAR KRISHI Geoportal on daily basis. Near real time crop condition monitoring was developed using google earth engine platform and moderate resolution satellite data.

Real time soil moisture-based irrigation scheduling of green pea revealed water saving of 44-50% against surface irrigation practice. Conservation practice, permanent beds with residue recorded highest grain yield of *kharif* crops followed by zero tillage and CT. Sugarcane based Integrated farming system developed by ICAR-IISR fetched additional income of ₹2,65,902.5/ha in autumn planted sugarcane and ₹ 2,63,020/ha in spring planted sugarcane. The wireless smart trap developed for real time pest monitoring in cotton showed a weekly mean trap catch of 19.8 (*P. gossypiella)*, 6.18 (*S. litura*), 0.19 (*H. armigera*) and 0.08 (*E. vittella*) during 2021-22.

Four mVOCs formulations evaluated @ 5 ppm concentration on the attraction of 4 sucking pests–whiteflies, jassids, aphids, and thrips in cotton using yellow sticky traps (YST) trapped 232%, 1517%, 709%, and 237% higher whiteflies, jassids, aphids, and thrips, respectively as compared to the control. Insect bioassay (*in vitro*) conducted to study the efficacy of the native strain of the *M. rileyi* on fall armyworm indicated *M. rileyi* as potential microbial agent for management of the fall armyworm in sorghum. The survey conducted to understand the infestation anddistribution of common bruchid species in legumes, indicated 5 bruchid species infesting pulses, 3 of which were *Callosobruchus*. Among *Callosobruchus* species, *C. analis* was distributed on 50% of the samples and locations, followed by *C. maculatus* and *C. chinensis*.

The formulations based on two *Trichoderma* species having excellent quality to protect the rice plant against soil and seed-borne diseases and excellent growth promotion capability developed and tested at farmers' fields. They were highly effective in maize, finger millet, niger and rice. Entomopathogenic nematode (EPN) biopesticide formulation technology was commercialized to 5 companies with a license fee of ₹10 lakhs. Efficacy of fungicide against rice bakanae disease was tested. Spraying of propiconazole @ 2 ml l^{-1} of water at 15 DAT resulted the lowest incidence of bakanae disease and higher yield of rice.

Soil application of mycorrhizal consortium @ 20 kg along with 500 kg of compost/ha at the time of sugarcane planting proved an effective bio-control of parasitic weed *Striga* spp. in sugarcane. A multi-residue analysis method was developed for simultaneous determination of 30 herbicides in agricultural commodities using LC-MS/MS. Similarly, a multi-residue analysis method using TLC with the detection limit of <0.01 µg/g was also developed for determination of herbicide combination products namely, pretilachlor + pyrazosulfuron, cyhalofop-p-butyl + penoxsulam and traifmaone + ethoxysulfruon. A user friendly multi-lingual mobile app named 'Herb Cal' for application of herbicides was developed. After entering the herbicide information such as crop, area, dose and herbicide formulation to be used, the app automatically calculates the amount of herbicide and quantity of water to be taken for spray. Biological control of alien invasive weed *Salvinia molesta* in a 20 ha *Salvinia* infested pond in village Padua of Katni district was achieved by releasing 2,000 adult weevils of a host specific insect *Cyrtobagous saliviniae.* With the increase of bioagent population 50, 80 and 100% control of *S. molesta* was achieved by 8, 11 and 18 months, respectively.

In grapes, microbe-based technologies, Eco-pesticide, Bio-Pulse, UBSTH-501 and Bio-Care 24 were evaluated against *Erysiphe necator* grape powdery mildew and integrated these technologies with a safer fungicide (sulphur). The percent disease index (PDI) reduced significantly in grape leaves treated with Eco-Pesticide®/sulphur (22.37) followed by Bio-Pulse®/ sulphur (22.62) and Bio-Care 24®/sulphur (24.62). An efficient technology for multiplication of clonal rootstock of apple through cutting under greenhouse conditions using soilless rooting medium was standardized. Field application of nanoparticles of iron and zinc showed a significant increase in leaf Fe and Zn content after 14 and 28 days of application over conventional fertilizers. The performance of Crimson Seedless, Manjari Kishmish and Manjari Medika grapevines grafted on Dogridge and 110R was found superior over other rootstocks. A microbial consortium CISH Decomposer has potential to accelerate the composting rate. DRIS indices and critical leaf nutrient concentrations were developed for oil palm plantations. Coconut-based Integrated Farming System (CBIFS) realized a net return of ₹ 6,53,853/ha.

Application of customized fertilizers in sweet potato was best for higher tuber yield (22.74 t/ha) compared to present POP (19.67 t/ha). Low cost technology for the paddy straw mushroom cultivation was developed. Vertical farming was standardized for growing important high value flower crops by utilization of 11 feet vertical space of the polyhouse. Nutritional and chemical finger

prints of popular turmeric varieties were developed. The effects of nanoZnO (nZnO) on the compositional and functional responses of bacterial communities in soils were examined using high throughput sequencing. Microbial consortia for enhancing the growth and yield of cumin and coriander was identified. Organic nutrient management practices for Sarpagandha were developed. New insect-pests in banana (Fall armyworm, *Spodoptera frugiperda;* Bondar's nesting whitefly, *Paraleyrodes bondari* and bagworm, *Manatha albipes*) were identified. Litchi stink bug (*Tessaratoma javanica*) and the Flower webber were recorded as emerging insect pest attaining major pest status of litchi. An algorithm based on object detection approach was developed for surveillance of rhinoceros beetle infestation using unmanned aerial vehicle (UAV or drone).

An entomopathogenic fungus isolated from infected *H. theivora* was identified as *M. anisopliae* TMBMA1 and found effective in mirid management in cocoa. Competitive regulation and biological control of rugose spiralling whitefly by the Bondar's nesting whitefly (BNW) during 2021 was observed. Incidence of Fusarium wilt disease, tropical race 4 (Foc TR4) in banana in West Bengal was identified. Citrus microbiome was utilized in rejuvenating Khasi Mandarin plants affected by important citrus diseases. Etiology of emerging diseases in plantation crops was established. A rapid and novel mycelium inoculation technique for inducing *Ganoderma lucidum* infection in coconut and arecanut seedlings was developed. A native plant growth promoting isolate of *Trichoderma asperellum* (isolate AT172) having antagonistic activity against arecanut basal stem rot pathogen *G. lucidum* was identified and characterized.

The cashew leaf blight disease caused by *Neopestalotiopsis clavispora* was identified for the first time in cashew. RPA-lateral flow assay (RPA-LFA) method was standardized for the on-site detection of the piper yellow mottle virus infecting black pepper. Singleplex and duplex recombinase polymerase amplification (RPA) assays were optimized for specific and sensitive detection of *Pythium* spp. and *Ralstonia pseudosolanacearum* from ginger rhizomes. Marker free late blight resistant transgenic line KJ66 was identified. Prototype of a remote operated unmanned ground (UGV) vehicle was designed and developed for spraying of agrochemicals on potato crop. Sodium alginate-based bead formulation of fungal mycelia and conidia for long term storage of fungal cultures were developed.

Livestock Management: Thirteen healthy buffalo calves (seven males and six females) were produced from semen of two cloned bulls. This technology will lead to future sustainable milk production in the country. Prototype of intra-vaginal wireless sensor device was developed for remote monitoring of calving process in dairy cows. This could help in predicting the calving time in cattle. NADRESv2, a dynamic geographic information and remote sensing-enabled expert system maintained by ICAR-NIVEDI was updated in the NADRES database, and a total of 5,655 predictions for major livestock diseases were communicated to State Animal Husbandry Departments and Department of Animal Husbandry and Dairying (DAHD), GoI, in the form of risk maps, bulletins, and post-prediction maps for necessary preparedness. Nation-wide sampling plans for sero-surveillance and sero-monitoring of foot and mouth disease (FMD), brucellosis, *Peste des Petits Ruminants* (PPR) and classical swine fever (CSF) for each state/UTs of the country were formulated and provided to DAHD, GoI, for strengthening the surveillance system. Screening of serum samples (32,257) for important livestock diseases from different animal species submitted to various NADEN units and State Animal Husbandry Departments was carried out. The sero-diagnostic services were provided for infectious bovine rhinotracheitis (IBR), trypanosomiasis and pasteurellosis with 28.9%, 49% and 4.5% positivity, respectively in ruminants. Brucella post-vaccination sero-monitoring is one of the major activities to evaluate the impact of the control program. Towards this, a total of 14,611 sera collected from different states were screened, of which, 64.45% were positive for anti-brucella antibodies.

Under FMD sero-surveillance, 98,185 bovine serum samples from around the country were analyzed and an overall sero-positivity in 16.6% of the tested samples was reported. The state FMD centers were provided with three main test kits (3AB3 indirect DIVA ELISA for 1,75,583 samples, Solid Phase Competitive ELISA (SPCE) for 1,56,778 samples, and Sandwich ELISA for 3893 samples. Clinical samples (2824) were analyzed for serotype identification in 378 FMD outbreaks. During 2021, all three FMD virus serotypes were documented, with serotype O leading the outbreak scenario followed by serotype A. Overall, the disease incidences have increased compared to previous year. A total of 113 FMD virus isolates (102 O, 10 A and 1 Asia 1) revived in BHK-21 cell system were added to the National Repository of FMD Virus maintained at International Centre for FMD, Bhubaneswar and Mukteswar Laboratory. PPR Ab Chek kit for the detection of PPR Virus nucleocapsid protein antibodies in the serum samples and PPR Ag Chek kit for the detection of PPR virus in Clinical specimens of sheep and goats; Recombinant nucleocapsid protein based indirect ELISA kit for detection of Anti SARSCoV-antibodies in canines (CAN-CoV-2 iELISA kit) and Multi recombinant proteins based ELISA Kit for diagnosis of *Trypanosoma evansi* infection in

animals; TaqMan-probe-based realtime RT-PCR assays (RT-qPCR) for pan-serotype detection of FMDV; Recombinase polymerase assay for detection of African swine fever virus in pigs; Multiplex PCR to differentiate Mycobacterium tuberculosis complex species; Rapid colorimetric assay for detection of the extended spectrum β-lactamase producing bacteria; Lateral flow assays (LFAs) for detection of CD virus antigen and antibody were developed. Among the vaccines, Ancovax for SARS-CoV2 infection; LSD vaccine named Lumpi-ProVacInd against LSD; Inactivated Low Pathogenic Avian Influenza (H9N2) vaccine for Chickens; Thermostable serotype O vaccine for FMD were developed. Mesenchymal stem cells (MSCs) with or without egg shell membrane, bioactive collagen gel, collagen powder, platelet rich plasma, and MSC laden Nano-scaffolds of hydroxyapatite and multiwalled carbon nanotubes were evaluated for skin wound, bone and nerve healing in animal models, and showed promising results. p38 mitogen activated protein kinase inhibition suppresses buffalopox virus (BPXV) protein synthesis by targeting p38-MNK1-eIF4E signaling pathway. The P60-SB239063 virus exhibited significant resistance to SB239063 as compared to the P60-Control virus. This is a rare evidence, wherein a virus was shown to bypass the dependency on a critical cellular factor under selective pressure of a drug. An online database management system named MHC Database was created (http://www.mhcdbms.in/) to allow easy access and use of immune polymorphism data. This system also allows user to upload as well as download the indigenous Ovar MHC allelic database for sheep breeds in FASTA format. CRISPR/CAS9 mediated knock-in of human Erythropoietin gene in the goat fibroblast cells was done and the transgenic goat fetal fibroblast cells expressed hEPO gene fused with green fluorescent protein (GFP) gene. ICAR-NRCE, Hisar is actively involved in glanders surveillance, providing diagnostic support, capacity building of state diagnostic laboratories/ RDDLs. For rapid and efficient execution of surveillance activities, Hcp1 ELISA kit developed by NRCE is being used for glanders diagnosis. A total of 1,737 equine serum samples from 8 states were tested for equine infectious anemia (EIA), equine influenza (EI), Equine Herpes Virus-1 (EHV-1), Japanese Encephalitis/West Nile Virus (JEV/WNV), *Trypanosoma evansi* (Trypanosomiases), piroplasmosis *Salmonella, Abortus equi* and brucellosis. Highest sero-prevalence was observed for equine piroplasmosis (38.40%) followed by EHV-1 (7.80%), JE/WNV (7.40%), and *Trypanosoma evansi* (2.15%). Stallion seminal plasma proteins were profiled and the proteins and pathways associated with sperm motility were identified. Purification, molecular characterization and ligand binding properties of the major donkey seminal plasma protein (DSP-1) isolated from donkey (*Equus hemionus*) seminal plasma was done. Transgenic chickens were produced through sperm mediated gene transfer (SMGT) method with an efficiency of 5.4%. In the transgenic birds, human interferon alpha 2b gene was introduced at the germ line stage in the chicken genome. The transgenic hens laid 132 eggs with an average content of 30-40 mg of interferon alpha 2b protein in each egg. Characterization of colostrum of native cattle and yak of high-altitude region of Leh-Ladakh was done in comparison to Sahiwal (SAC). Samples from LSD suspected outbreaks in 20 States/UTs of the country were tested to identify laboratory confirmed cases of LSDV infection for undertaking prevention and control measures against LSD in India. A total 2,456 bovine (cattle and buffalo) samples were tested, of which 1,156 cattle samples from 19 States/UTs tested positive for LSDV. First whole genome analysis of Indian African swine fever viruses revealed potential genetic determinants to differentiate closely related ASFV circulating in Asia. Global alignment of the complete genome sequences showed nucleotide identity of 99.96% amongst the two Indian isolates (IND/AS/SD-02/2020 and IND/AR/SD-61/2020). The results showed the importance of the 14 ORFs in understanding the evolution of ASFV in Asian countries and their divergence from prototype ASFV Georgia/2007. Whole Genome Sequencing of 12 Bovine coronaviruses isolated from cow (3) and buffalo (9) nasal and faecal samples collected in 2020-21 revealed two different subgroups: subgroup GIa having 9 viruses cluster from across the world and GIb subgroup having 3 other viruse cluster which has majorly the isolates of France in 2017. A food-grade meat decontaminant spray was developed by using the extracts of Ashwagandha roots and Guava leaf spray which could reduce the microbial load many folds in retail fresh chicken. Phytochemicals (thymol and cinnamaldehyde) conjugated silver nanoparticles (AgNPs) were tested for their efficacy against Enteroaggregative *Escherichia coli* (EAEC) and non-typhoidal *Salmonella*. Assays revealed the antimicrobial activity of the encapsulated compounds (EAgC and EAgT) and appeared to be safe.

Fisheries Management: A web-GIS application for location-specific riverine fisheries management was developed. It provides an interactive and user-friendly interface which contains environmental data of 300 sampling stations covering 20 major rivers of India. The portal's database and customized reports will facilitate various researchers, planners and policymakers to make judicious planning/strategies for the betterment of fisheries resources**.** Mud crab, *Scylla serrata,* is an economically important crustacean species which is also being cultured. Mud Crab Reo Virus (MCRV) is

an emerging viral pathogen in mud crab culture. On RT-PCR screening, MCRV were detected in gills and hepatopancreatic tissues. Herpesviral haematopoietic necrosis disease (HVHND) is caused by CyHV-2, which causes severe mortality in goldfish. A rapid and sensitive RPA (Recombinase Polymerase Amplification) assay, coupled with lateral flow dipsticks (LFD) was developed by designing specialized RPA primer, LFA primers and probes. The RPA-LFD assay developed presents a simple, rapid and sensitive method for point-of-care diagnosis of CyHV-2, especially under resource limited conditions. A Coliphage cocktail for controlling antimicrobial resistant (AMR) *E. coli,* containing 10 coliphages, selected based on their broad host range, varied location and their ability to lyse AMR *E. coli* was developed. The Coliphage cocktail has a phage titer of ~10^{12} to 10^{14} pfu/ml and can be used for the control of *E. coli* and AMR *E. coli* on food contact surfaces. The Coliphage cocktail can be stored under chilled conditions (<4ºC) condition for a minimum period of 3 months.

Soil and Water Productivity: Micro level agricultural land-use planning, soil and water conservations, water harvesting, storage and groundwater recharge, improvement in water productivity and nutrients use efficiency, integrated nutrient management, resource conservation technologies, chemical free agriculture, integrated farming system, waste-water use, dryland, hill and coastal agriculture, weed management, precision agriculture, climate resilient agriculture, abiotic stress management was given special thrust. The land resource inventory (1:10,000 scale) for Bundelkhand region prepared for sustainable land use, spectral signature library of the soils of India for quick and inexpensive acquisition of surface soil properties, potential crop planning zones of Telangana, and land suitability analysis for turmeric in Kerala under projected climate change scenarios were accomplished. The groundwater quality map of Madhya Pradesh for irrigation and groundwater recharge plan for Korba and Janjgir-Champa districts in the upper Mahanadi Basin developed. ICAR-CSSRI and NTPC joint study on efficiency of flue gas desulphurization gypsum (FGDG) revealed 8-11% decline in saline soil pH after one year of FGDG surface application (0-15 cm depth) and neutralization of soil alkalinity improved paddy yield by ~40%. A Solar Irrigation Pump Sizing Tool (SIPS) was developed for large scale adoption by farmers and support the PM-KUSUM initiatives. To promote organic farming, packages for 5 cropping systems for Gujarat, Rajasthan an Uttarakhand were developed. ICAR-NIASM developed beta version of the Abiotic Stress Information system (ASIS) consisting of modules on Atmospheric and Soil Stress information for generating query based geo-spatial maps. The new salt tolerant varieties in rice (CSR 76) and mustard (CS 61 and CS 62) developed.

Mechanization and Energy Management: A tractor operated side trencher was developed to make trench up to 300 mm depth. The effective field capacity and field efficiency of the trencher were 0.2 ha/h and 71%, respectively when operated to dig a trench of 300 mm deep in 3 m wide vineyard at 2.0 km/h forward speed. The cost of operation of tractor operated side trencher is about ₹ 560/hr. It economizes the cost of operation, labour and time by 72, 94 and 80%, respectively as compared to manual digging of trench with hand tools. The tractor operated FYM applicator of 1 tonne capacity developed for placing FYM near the plant. The cost of operation of tractor operated FYM applicator is about ₹ 645/hr which saves labour, time and cost of operation by 98, 80 and 88%, respectively as compared to manual method. Manual operations of raised bed forming, drip lateral and plastic mulch laying, and planting seeds in a plastic mulch requires about 29 man-days/ha. A tractor operated drip lateral and plastic mulch layer-cum-planter has been developed to perform raised bed formation, drip lateral and plastic mulch laying etc in single pass of the tractor. The total cost of equipment is ₹3,00,000 with operational cost of ₹ 1,500/hr. The payback period of equipment is 1.9 years. A self-propelled walk-behind maize harvester for snapping the maize cobs from the maize plants and simultaneously cutting the plants has been developed. The effective field capacity of the harvester is 0.2 ha/hr and the cost of operation of the maize harvester is ₹ 2,850/ha. The saving in cost of operation, time and labour are 25, 96 and 91%, respectively compared to manual harvesting. A remote-controlled electronic system has been developed for ride-on rice transplanter to reduce human drudgery. It can be remotely operated at a distance of 200 m. The field capacity of remote-controlled ride-on rice transplanter is 0.24 ha/hr. To ease the digging of garlic, a tractor operated harvester has been developed which can harvest garlic crop planted on raised beds. The harvesting efficiency of the harvester is 97% and bulb damage is <0.5%. A small tractor-mounted hydraulic pruner for orchards has been developed with the pruning capacity of 120 plants/hr. The cost and operating cost of the pruner is ₹ 4,50,000 and ₹ 4,910/ha, respectively. ICAR-CIAE has developed a low-cost SPAD meter 2.0. It measures SPAD values for crops such as rice, wheat, maize, etc. with leaves up to 1 mm thickness. The SPAD values, measured with the device, can be used to generate recommendations for top-dressing of nitrogen fertilizer dose. A small tractor operated boom sprayer has been developed for orchard crops. The cost of the spraying system is ₹ 30,000. The discharge rate of boom sprayer was 608 l/hr at 0.3 MPa pressure. The application rate and turning time of the spraying system was 475 l/ha and 12 s, respectively.

A power tiller operated groundnut digger has been developed with field capacity of 0.07-0.11 ha/h and digging efficiency of 97.6%. A tractor operated potato digger developed which performs three operations, viz. digging of potato tubers (two rows), separation of potatoes from soil and collection of potatoes in the collection unit. The average field capacity and output capacity have been 0.12 ha/hr, 2,700 kg/hr for sandy loam soil and 0.11 ha/hr, 2,685 kg/hr for loamy soil, respectively. A digital flume with the Internet of Things (IoT) connectivity has been developed and tested to continuously measure the flow rates in open channels. Utilizing the IoT, the developed digital flume measures the discharge and transmits data wirelessly for storage on cloud (ThingSpeak). It was tested in the field under varying discharge conditions in the field channel. It can be utilized for irrigation water measurement in the field channel for management of available irrigation water.

Post-harvest Management and Value-addition: Post-harvest treatment machines for pre-cooling, washing, warm water treatment, anti- microbial treatment, anti-browning, and pulsed light treatment to the freshly harvested fruits and vegetables developed. It also has an inspection conveyor to sort out the deformed and damaged products. The capacity of the machine is 1.2 t/hr for capsicum,1.0 t/hr for apple at a linear belt speed of 5 m/min.The peeling machine for medicinal tuber crops has been developed with peeling efficiency of ~ 92% for *Safed musli* and 55% for *Shatavari* and capacity of ~15-20 kg/hr which is thirty times higher than manual operation. An electronic sensing system (e-Nose) has been developed in collaboration with C-DAC Kolkata for the real-time health monitoring of the onions, potatoes, and tomatoes in storage. The machine for popping of sorghum, amaranth, finger millet, kodo millet, and other small grains including rice, and corn developed with a capacity of 1.4-2 kg/hr and 60-70% popping recovery for sorghum and amaranth. To provide easy, fast and non-destructive method for detection of pea flour adulteration in *besan*, near infra-red spectroscopy (NIRS) model has been developed which can be used to predict adulteration of *besan* with pea flour. A novel process based on microbial precipitation process to produce protein isolates/concentrates from oilseed cakes/meals has been developed. This method increased 5% yield as compared to the chemical process. The protein produced is superior in terms of solubility, wettability, water absorption capacity and degree of hydrolysis. Multi-nutrient biscuits with high satiety value, appealing taste and 21% higher acceptability on a sensory scale over commercial biscuits. The cake formulation consists of malted *ragi*, *amaranth* and sprouted soybean forming gluten free flour, banana and yoghurt as egg replacer complex and cholesterol free vegetable oil instead of saturated fat which makes it rich in protein (5 g), minerals (1.4 g), iron (4.5 mg) with good antioxidant activity for 100 g of cake. This is a unique egg less preparation and best suited for people who have gluten allergy. Re-using the existing fibres and textiles, reduces the need for newly manufactured fibres and saves water, energy, dyes and chemicals, which reduces the carbon footprint. The fibres were extracted from pre-consumer cotton knitted fabric waste and converted into yarn by blending this recycled cotton fibre (RF) with virgin cotton (VC) fibre in different blend proportions.The blending in 50:50 (RF:VC) provided better yarn properties and more suitable for home textiles applications such as bed linen, furnishing fabrics, interior decoration accessories etc. Electro spun nanofiber-based micronutrient delivery matrix was developed to enhance the nutrient use efficiency, as compared to bulk nutrient application. The needle electrospinning machine was used to produce zinc sulphate impregnated electro spun nanofiber mat. The banana pseudo stem has potential for extraction of textile fibres, sap for dyeing and finishing, and other portion for making paper-based products. Semi-solid banana plant biomass was used for making paperboard, similar to paper with higher areal density and they are comparable with conventional handmade paper. Application of activated carbon derived from jute stick, NINFET-JAC, as an alternative to graphitized carbon black, was found effective for pesticide residue analysis in various crops like okra, spinach, pomegranate, tea etc. Sheep wool contains about 95% keratins which have huge applications in medical and pharmaceutical industries. Coarser grade wool having no textile use can be used for extraction of keratin. ICAR-NINFET has developed a microbial protocol for keratin extraction from animal hair. Fibre producing species of nettle are European nettle and Himalayan nettle. NINFET has developed 100% nettle, nettle/viscose (75:25, 50:50,25:75), and nettle/polyester (75:25, 50:50, 25:75) blended yarn and also union fabrics using cotton yarn in warp and these nettle-based yarns in the weft. These blended fabrics are suitable for fashion apparel, garments, shawls, stole, scarf, saree etc.

Climate Resilient Agriculture: In recent years, land-atmosphere coupling in many parts of the world has been identified to have raised temperatures and aridity. Studies using consistent methodology and metrics from multiple data sources established that the drying land surface turns into a source of heat generation and drought exacerbation due to reduced evaporative cooling and increases atmospheric heating from sensible heat flux. The land suitability for turmeric cultivation in Kerala was analyzed using HadGEM2 Model based on the Representative Concentration Pathway (RCP)-4.5 for climate projection scenario of turmeric in 2050. The

projections revealed increase in highly suitable area by 5% from 28% to 33% and decrease of 4% from 11% to 7% in non-suitable areas of turmeric which could positively contribute to its production. The spatio-temporal changes in maize yield studied using multi-model ensemble climate change projection derived from 30 general circulation models in 16 major maize growing districts of India. The projected reduction in maize yield is 16% to 46% under RCP4.5 and 21-80% under RCP8.5 without adaptation strategy. The combined adaptation strategies might reduce the loss in yield or even increase by 5-15% under RCP4.5 scenario. Rice-based IFS model for lowland conditions of West Coast and IFS model for dryland of Karnataka and transitional plain of Luni basin developed. Swarna Unnat Dhan (IET 27892), rice variety with multiple stress tolerance developed for irrigated transplanted condition of Bihar, Odisha, West Bengal, Madhya Pradesh and Maharashtra. Genome editing technology (CRISPR-Cas9) was used to create loss of function in mutants of the *DROUGHT AND SALT TOLERANCE (DST)* gene, a zinc finger transcription factor, in rice cultivar MTU 1010. Three homozygous mutants developed with reproductive stage tolerance to salinity stress. These lines were evaluated further for yield under drought stress and non-stress conditions. Under drought stress (-75 KPa), genome edited mutants showed significantly higher grain yield as compared with MTU 1010.

Human Resource Development: Strengthening and development of higher agricultural education and quality assurance of AUs through accreditation and ranking process are the two major areas supported by ICAR. The strengthening of ICT facilities in AUs, emphasis on capacity building of the students and faculties through various training programmes under ICAR scheme as well as NAHEP helped enhance the capabilities of the faculties in various upcoming areas and improved the publications. AUs were also supported for encouraging holistic development of students, through creation of placement cells, support for sports facilities.The centralized admissions and national/international fellowships by ICAR helped improve academic ecosystem, and encouraged merit across AUs. National Professorial Chairs and National Fellow Scheme for promotion of excellence in research, Emeritus Scientist/ Emeritus Professor Schemes as a structural method of utilizing skill bank of the outstanding superannuated professionals in various disciplines to address faculty shortage. NAARM contributes immensely on wide range of issues of national and global importance apart from various courses on capacity building. The Academy has also been promoting online and digital education, startups for agripreneureship.The key components of NAHEP, viz. Centres for Advanced Agricultural Sciences and Technology (CAAST), Institutional Development Plan (IDP), and Innovation Grants have contributed to enhanced entrepreneurship opportunities and other reforms in AUs.

Social Science: The impact of different risk management strategies on farm productivity and its resilience to climatic shocks was estimated. Measures were categorized into risk-mitigating, risk-transferring and risk-coping strategies. Productivity and risk effects of crop insurance vis-à-vis irrigation to explain the low uptake of crop insurance. Both crop insurance and irrigation positively impact farm productivity, but their gains differ significantly. The structure of rural employment is undergoing a change. The withdrawal of the agricultural workforce has further accelerated, and an additional 28 million workers left between 2011-12 and 2017-18. In the recent decade, the agricultural sector has experienced all-time high growth of 3.5%, and the growth has been driven by the animal husbandry and fisheries. The feasibility of a uniform water pricing policy and a differentiated water pricing policy was assessed. A notable shift in cropping patterns will take place when a volumetric and differential water pricing policy is adopted. Possibilities of reducing import dependence to meet the edible oil demand by increasing domestic production, adopting yield-enhancing technologies, and raising import tariffs, was investigated.

A general method of construction of row-column designs with two rows for orthogonal estimation of main effects and two factor interactions in minimum number of runs was given for orthogonal parameterization. An alternative sampling methodology for estimation of area and production of horticultural crops developed by ICAR was adopted by Department of Horticulture, Government of Haryana. Developed a support vector machine-based prediction model for predicting GIGANTEA proteins in plants. Based on the developed methodology, a prediction server GIpred has also been established which is freely accessible (http://cabgrid.res.in:8080/gipred/) for proteome-wide recognition of GIGANTEA proteins. Developed machine learning-based models for identification of abiotic stress responsive miRNAs and Pre-miRNAs in plants. Developed a comprehensive machine learning based computational model for discovery of DNA binding proteins in plants (PlDBPred) that play crucial roles in numerous cellular processes. Developed prediction server PlDBPred which is publicly accessible at https://iasri-sg.icar.gov.in/pldbpred/. The miRNA profile prediction system was implemented as a webserver available at https://scbb.ihbt.res.in/miRbiom-webserver/ and also the standalone version available at Github (https://github.com/SCBB-LAB/miRbiom). Citation analysis of publication during

2007-2020 showed increase in that total number of publications, total citations, average citation per paper, impact factor per paper, number of papers in journals with impact factor≥4. ASRB-Online Application and Scorecard Information System (ASRB-OASIS) application (http://www.asrb.org.in/) was developed for inviting online applications for the RMP positions and Non-RMP positions. Academic Management System (AMS), a web-based application, aimed at automating administrative and academic activities of agricultural universities was adopted in 56 universities. ICAR carried out research activities focusing on farm women nutrition, livelihood enhancement, technological empowerment, drudgery reduction and entrepreneurship development. In rural areas the participation of women (6yr+age) in overall agriculture, crop sector and livestock sector were 22.4, 13.3 and 10.7% and their contribution were 30.8, 27.2 and 45.8%, respectively. The survey conducted to understand the knowledge level of farm women on nutritional aspects indicated that nutritional awareness among farm women increased to 60% as compared to the pre-project status of 15.5%. A pan-India nutri-smart village project was designed for promoting nutritional awareness, education and behavioural change in rural areas involving farm women and school children through local recipes to overcome malnutrition, implementing nutrition sensitive agriculture through homestead agriculture and nutri-gardens. Twenty-eight capacity building programmes were organized for potential women entrepreneurs in the identified areas which benefitted 902 rural women.

Basic and Strategic Research: Genome editing technology (CRISPR-Cas9) was used to create loss of function mutants of the drought and salt tolerance (*DST*) gene, a zinc finger transcription factor, in rice cultivar MTU 1010. *DST* gene mutants showed >25% increase in grain yield under normal conditions due to increase in reproductive tillers per plant and grain number per panicle. Phenotypic variance of 436 rice accessions from the sequenced panel of 3,000 rice genome accessions was assessed at multiple locations to identify superior donors and alleles for spikelet fertility and low grain chalkiness under thermal stress. Three rice accessions with consistently high spikelet fertility under high temperature, seven accessions with low chalk and eight accessions with cold tolerance were identified. A panel of 150 diverse accessions from the 3K rice genome panel of IRRI was assembled and extensively phenotyped in the Phenomics Facility under well-watered (100% FC) and limited water (60% FC) conditions to identify QTLs for subcomponent traits of WUE. Fine mapping and marker-assisted breeding for alternative dwarfing genes *Rht14* and *Rht18* was done to develop semi-dwarf wheat genotype suitable for conservation agriculture. Germplasm comprising 400 accessions including wild relatives and progenitors of wheat phenotyped for heat stress tolerance was genotyped using 35K Axiom SNP chip to identify the novel genes/QTLs. In order to identify the genomic regions and genes for drought and heat tolerance in groundnut, eight parents and 500 lines of the MAGIC population, 432 RILs of TMV2 × TMV2-NLM and 250 RILs of JL 24 × 55-437 were subjected to DNA sequencing.

The maize genotypes, viz. CML 44 BBB (3.0), DML 163-1 (3.5), IML 16-248 (4.0) were found promising against fall armyworm *Spodoptera frugiperda*. In order to impart resistance against Papaya Ring Spot Virus (PRSV), a high throughput papaya transformation and regeneration protocol towards genome editing of the eIF4E gene family was established and CRISPR/Cas9 mediated editing of eIF4E gene family was undertaken.

Targeted editing of the potato genome to develop variety specific True Potato Seed (TPS). A total of 285 banana mats/genotypes collected from different groves of North Eastern (NE) states were characterized for endogenous banana streak viruses (eBSV), which indicated the prevalence of distinct/novel alleles having similarity to endogenous banana streak OL virus (eBSOLV), banana streak IM virus (eBSIMV), banana streak GF virus (eBSGFV) and *Musa balbisaina* PKW type activable alleles, the allelic positions of which make them activable. Full genome sequence of a new badnavirus banana streak MH virus (BSMHV) associated with streak disease of banana cultivar *MeteiHei*(ABB) grown in Manipur was achieved. Soil Zn application as nano-ZnO (nZnO) or bulk ZnO (bZnO) induced marked shifts in bacterial community structure, with dominance of *Sphingomonas* and *Nitrospira* under nZnO exposed soils, while *Bryobacter*, *RB41*,*Candidatus solibacter* and *Flavi solibacter* dominated under bZnO exposed soils. A sensor was developed for the efficient detection of Cr (VI) in water with a linearity range 100 ppb to 1 ppm. The sensor was incorporated into a hand-held prototype device. Another aptamer-based biosensor was developed for the detection of fish pathogenic bacteria *Aeromonas veronii*. The sensor is able to specifically detect *Aeromonas veronii* and shows no cross-reactivity with other bacteria.'Ekcel decomposer' consortia was prepared; and the drum type composting unit and shredder machine, viz. 'Ekcel Composter'and 'Ekcel Shreder'were also fabricated, which help in accelerating the decomposition of different bio-waste. The 'Ekcel decomposer capsule' was also developed and released. The four bio filters were designed and prototypes were developed for safe wastewater irrigation. Thirteen clones of 6 superior breeding male and one elite buffalo female were produced. A calf of an

earlier cloned bull Hisar-Gaurav was also successfully re-cloned. A targeted immobilization method was developed, using iron nano particles conjugated with the developed antibodies (polyclonal), to immobilize the Y-Chromosome bearing spermatozoa. Cattle embryos produced through developed immobilization technique resulted in production of 72- 76% of female embryos. Similarly, a model for assessment of sperm-oviduct binding was developed for cattle. CRISPR/CAS9 guided functional analysis of genes regulating early embryonic survival in buffalo was done. An inexpensive, yet efficient, methodology for microinjection of CRISPR/Cas9 constructs into mouse zygotes was developed. Two approaches were attempted for the production of embryos. The embryo production rates (30-35%) were similar to non-edited control cells. The transfection and handmade cloning protocols were optimized in goats. indigenous transfection buffer was developed and tested in buffalo and goats. Developed buffer has 20-25% genome editing efficiency, and can be efficiently used to deliver CRISPR components/transfection materials into any mammalian somatic cells.

A recombinant nucleocapsid protein (NP) based indirect enzyme-linked immunosorbent assay (iELISA) kit Can-CoV-2 ELISA Kit was developed for detection of antibodies against SARS-CoV-2 in canines. The assay is 95.66% sensitive and 93% specific. The phytochemical conjugated silver nanoparticles (AgNPs) were encapsulated to achieve targeted delivery using chitosan-alginate polymers by ionic gelation method to combat antimicrobial resistance in poultry. All the tested encapsulated leads appeared to be safe (secondary cell line-based MTT assay and commensal gut lactobacilli. Evaluation of selenium in the diet of male growing goats under endotoxin-induced stress conditions indicated that crude protein digestibility tended to be high in higher selenium-fed animals, however, no effects on growth, nutrient intake, and digestibility were reported.

Dendritic cell platforms for *in vitro* and *in vivo* studies of antigen processing and presentation in cattle for combined vaccine antigens using FMD virus and *Pasteurella multocida* as model were generated. To exploit the adjuvant potential of mesoporous silica nanoparticles (MSN) to thermo stabilize the PPR vaccine virus (PPRV), four types of MSN were synthesized and characterized. Captive brood stocks of hilsa, *Tenualosa ilisha* were developed at three locations with fresh water system at Rahara, intermediate water system at Kolaghat and brackish water system at Kakdwip.Females collected from both captive and river were in similar stage of reproductive maturity while the captive male (av. body weight 122.33 ± 3.38 g) showed advanced maturation (GSI 2.24 ± 0.025) compared to wild male (238.67 ± 4.67 g) with maturing phase (GSI 0.768 ± 0.002). An automated anesthetic device was developed for safe handling and performing procedures related to reproductive interventions under stress condition and tested on wild and pond-reared hilsa. It can deliver optimum amount of anesthetic solution with desired flow over the gills through buccal cavity. Two qRT-PCR assays targeting TiLV genome segments 1 and 10 were standardized and employed to determine the viral load in liver, brain and spleen tissues of experimentally-infected tilapia. The assays detected higher viral load in liver than that determined in spleen and brain at all-time points post-infection. The study revealed an increasing trend in the viral load in the early stages of infection and a steady decline in the later stages. Further, the newly designed real-time PCR assay targeting TiLV genome segment 10 showed high sensitivity and can be used for the reliable detection of the virus.The four models of technology delivery through FPO were developed for seed production, vegetable production, organic farming and natural resource management for eastern region of India. The communication pattern of FPO and Non-FPO farmers was assessed through Social Network Analysis. The cohesiveness, sparsity and degree of influence of FPO were better than non-FPO farmers. An android mobile application-CIBA ShrimpKrishiApp was developed and launched for handholding the shrimp farmers to make real-time based informed decisions at farm level. The app is free and available in four languages, viz. English, Hindi, Tamil and Telugu.

Information, Communication and Publicity Services: The SPARROW, an online system for Annual Performance Appraisal Report (APAR) of non-scientific ICAR employees introduced in 2022 forfilling, submission, reporting and reviewing of APAR. Similarly, eHRMS, ICAR eOffice, ICAR DARPANDashboard, Land Record Management Information System, KISAN SARATHI, NePPA, etc have been developed for facilitating the official work.

Media and Information Unit assists in press coverage and public relations, showcasing the ICAR technologies through national and international exhibitions and production of documentary films. The Unit prepares and release of advertisements through print and electronic media. During the year, four documentary films were produced namely ICAR Technologies, ICAR at a Glance, ICAR Achievements and C. Subramanium Convention Hall. About 51 exhibitions were conducted in different states which included Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Jharkhand, Delhi, Haryana, Himachal Pradesh, Kerala, Assam, Meghalaya, West Bengal, Odisha, Bihar, Punjab and Jammu and Kashmir and India International Trade Fair. Exhibitions were

also organised in 68 institutes of ICAR. The Information and Publicity Unit under DKMA took the initiative in preparation of Concept note on International Year of Millets 2023 for participation of ICAR through tableau in Republic Day Parade which has been accepted.

Technology Assessment, Demonstration and Capacity Development: During the period under reporting, 7 new KVKs were established taking the total number of KVKs in the country to 731. A total of 6,198 technological options in different crops were assessed at farmers' fields under 31,532 trials at 14,155 locations focusing on varietal evaluation, INM and IPM thematic areas. About 1,097 technological options pertaining to nutrition and other thematic areas in livestock production and management at 2,516 locations through 6,210 trials; 471 technologies under farm and non-farm enterprises at 1,040 locations through 6,124 trials; and 371 technologies pertaining to farm women under 3,222 trials at 756 locations were also assessed. Health and nutrition and value addition were the major thematic areas of technologies assessed with an aim to promote women empowerment.

The demonstrations on improved technologies of pulses and oilseeds numbering 48,473 and 46,519 on 17,973.95 ha and 18,301.31 ha respectively were conducted during reporting period. Among 33,588 FLDs on cereal crops, 10,661 FLDs were conducted on 231 technology options in wheat varieties and management technologies in 3,724.04 ha area; in rice 504 varietal and technology options under 18,848 FLDs in 4,625.52 ha; 3,616 FLDs on 131 varietal and technology options in maize on 1074.76 ha area. Among 3,030 FLDs on millets, 48 varietal and technology options were demonstrated on finger millet by 52 KVKs in 1,278 FLDs. Varieties and technologies on pearl millet (35) and sorghum (35) demonstrated in 633 and 500 FLDs, respectively. In pulses, total 12,206 FLDs were conducted on 533 varietal and production technologies options. It included 3,463 FLDs on chickpea, 2,461on blackgram, 1,911 on greengram, 1,702 on lentil and 1,415 on pigeon pea. A total of 9,353 FLDs on 439 varieties and management technologies of oilseed crops conducted including 2311 on mustard, 2,088 on rapeseed, 1,636 on soybean, and 1507 on groundnut. In horticultural crops, altogether, 27215 FLDs were conducted on 1,635 varieties and technologies comprising vegetables (18,514), fruits (3,628), spices (3071), flowers (594) and medicinal and aromatic crops (143) in 5342.1 ha area. In commercial crops, 1,530 FLDs in sugarcane and 1,074 FLDs in cotton were conducted. Demonstrations on forage crops such as berseem, maize, sorghum, Napier grass, etc., were conducted at 3,738 farmers' fields on an area of 495.3 ha. KVKs conducted 7,973 FLDs on 310 hybrids covering an area of 2372 ha in cereals, millets, oilseeds, pulses, fodder crops, commercial crops and horticultural crops. Total 777 technology options on improved tools and farm implements were demonstrated in 17,121 demonstrations were covering an area of 9,750.37 ha. In animal husbandry and dairying and fisheries, 16,983 and 1,617 demonstrations were conducted. KVKs conducted 16,880 demonstrations on 20 enterprises which facilitated establishment of 23,383 enterprise units. Total of 21.16 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 69,550 training programmes including the sponsored training courses. Besides, KVKs also organized 5.68 lakh extension programmes and disseminated the latest technologies of agriculture and allied sectors among 160.85 lakh participants (157.79 lakh farmers and 3.07 lakh extension personnel).

One of the important services that KVKs offers to farmers is providing quality seeds and planting materials to them free of cost or on a nominal charge. During the year, 1.76 lakh quintal seeds of improved varieties and hybrids various crops to 2.89 lakh farmers and 497.40 lakh quality planting materials of elite species of field and horticultural crops, medicinal and aromatic plants and forest species to 5.01 lakh farmers were provided. The bio-products such as bio-agents (998.59 q), bio-pesticides (1455.16 q), bio-fertilizers (23,767.38 q), vermi-compost, mineral mixture etc., were produced and supplied benefiting 2.71 lakh farmers. Improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 56,203 farmers. Different strains/breeds/eggs of poultry birds to 44,170 farmers and improved breeds of pigs to 729 farmers were also provided. The KVKs also enabled 105 farmers to establish small rabbit rearing units by providing 915 rabbits. A total of 289.24 lakh fish fingerlings were produced and supplied to 9,586 farmers. For soil, plant and water health management, KVKs tested 3.10 lakh samples including 2.63 lakh soil samples, 8,368 plant samples, 37,956 water samples and 383 other samples like fertilizers, manures, food etc. benefiting 3.12 lakh farmers of 50,914 villages. A total of 2.22 lakh Soil Health Cards were issued to farmers.

During 2021-22, 4.33 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems and purchasing crucial farm inputs. In addition, 30.19 lakh farmers benefited from technological services provided by various ATICs. During the year, 4,340 entrepreneurial units were established benefiting 6,610 rural youth under ARYA. Under NICRA, 6,477, 13,931, 7,187 demonstrations were conducted covering 5,695.81, 6,807.6 and 265.65 ha of area under NRM, Crop and Livestock modules, respectively.

Mera Gaon Mera Gaurav (MGMG) programme was implemented through 127 institutions including ICAR institutes and SAUs by 1,054 groups of 4,315 scientists and covered 3,680 villages. Altogether, 37,982 field activities conducted and 27,958 advisories sent benefiting 5,05,303 farmers. Under Farmers First, 36,496 demonstrations and 2,649 extension programmes were organized. TSP KVKs conducted 4,634 training attended by 1,21,809 farmers. Under NATI programme, 16,681 nutri-gardens were established benefiting 30,310 farm families. KVKs also organized activities for promotion of nutrition garden, nutri-*thali*, value-addition, biofortified crops, etc. Total 2,657 training programs benefiting 81,633 participants and 4,161 extension activities benefiting 1,37,674 participants on nutrition literacy were conducted. Total 6,811 training conducted under SCSP which were attended by 1,18,485 farmers. Seed-hubs were set-up at 95 KVKs for production of quality seeds of major pulse crops. During the year, 42,835.07 q seeds of pulses were produced and made available to farmers. For crop residue management, demonstrations on CRM machinery on >20,000 ha including 3,000 demonstrations on decomposer technology was conducted. Total 3,778 IFS units were established on 88,406.19 ha. Total 5,894 IFS demonstrations and 9,512 trainings were conducted for 75,058 and 1,17,010 farmers respectively. Advisories on crop and livestock production/protection technologies in 15 different regional languages were circulated among farmers. Total 2,351 interventions to facilitate information about marketing of farm produce benefitting 5.42 lakh farmers were undertaken.

Research for Tribal and Hill Regions: For promotion of quality seeds of improved varieties in these disadvantaged areas, 16.138 tonnes breeder seed of 46 varieties/inbreds of 17 crops was produced and 13.121 tonnes breeder seed supplied to seed producing agencies for further multiplication. Besides, 1,313 kg nucleus seed of 49 varieties of 17 crops and 655 kg Truthfully Labeled seed of 20 varieties of 13 crops were produced. Including the carry-over stock, about 402 kg TL seed was supplied to different stakeholders. VLQPM Hybrid maize released for cultivation in North Western Hill Zone and North Eastern Hill Region. VL *Dhan* 69 released for Uttarakhand, Sikkim and J&K. For Uttarakhand, Maize, VLQPM Hybrid 61, and VLQPM Hybrid 63; wheat, VL *Gehun* 2028 and VL *Gehun* 3010; rice, VL *Dhan* 210, VL *Dhan* 211 and VL *Dhan* 70; lentil, VL 150; and field pea, VL 64 were notified. A total eight micro watersheds comprising dairy-based land use, mixed forestry, silvi-pastoral land use, agro-pastoral system, agri-horti-silvi-pastoral, silvi-horticultural system, natural forest block and timber-based land-use system developed and evaluated on a long term basis in Meghalaya. The integration of crops and livestock resulted in maximum income (₹ 2,71,400) and employment generation (252 man-days excluding family labour). For jhum improvement, one agri-horti-silvi-pastoral system in 1.58 ha developed. The system produced 6,846 kg of rice equivalent yield with a net return of ₹ 62,961. Integrated Organic Farming System (IOFS) models were established at Tripura and Meghalaya. The Tripura model gave a net return of about ₹ 73,990 and employment of 67 days which is quite high compared to existing farming systems. About 70% of the nutrient requirement of the model was met from nutrient recycling within the model. The Meghalaya model recorded a total net return of ₹ 83,360 per year which is much higher than the region's farmer common practices of rice mono-cropping or improved practice of the rice-vegetables cropping system. Approximately 96% of the total N requirement, 87% of the total P_2O_5 requirement and 99% of the total K_2O requirement could be met within this model thus making it a self-sustainable one. Ten high yielding stress tolerant crop varieties were released for north eastern hill region. Fly Cocobot-a drone-based remotely controlled unmanned gender-friendly coconut harvesting and crown-clearing machine for safe harvesting of coconuts was developed. This device can be used in mixed cropping plantation of coconut and black pepper. The machine is conceptualized jointly by ICAR-CCARI and Goa University and have operational efficiency of 12-15 palms/hr.

IP, Organization and Management: During the period under report, 78 new Patent Applications were filed making total to 1,455 applications. Indian Patent Office (IPO) had published ICAR's 37 patent applications in this period and granted 47 patent applications, taking ICAR's cumulative number of granted patents to 455. In this process, 31 ICAR institutes were involved to protect their innovations. To protect the Plant Varieties, 31 varieties (19 extant and 12 new varieties) were filed at Plant Varieties and Farmers' Rights Authority (PPV&FRA). For applications filed earlier, 21 varieties (19 extant and 2 new) were granted registration certificates. The cumulative total for plant variety protection applications rose to 1,381. Total 661 formal Licensing Agreements were formed up with 452 public and private organizations and entrepreneurs involving 55 ICAR institutes. Eighteen ICAR institutions entered into 80 agreements for consultancy/contract research and services with 75 public and/or private organizations. To enhance the agri-business environment 494 stakeholders were facilitated by 50 ABIs for their business incubation activities and motivated entrepreneurs/startups to initiate their own business. In reporting period these centres had facilitated 449 such stakeholders for their business incubation activities. These efforts motivated 146

entrepeneurs/startups to initiate their own bussiness.

The Rajbhasha saptah/pakhwara/mah was organized at ICAR Headquarters and its institutes. The Rajbhasha Ullas Pakhwara was organized during 16 to 29 September 2022 which was marked by inspiring messages of Hon'ble Minister of Agriculture and Farmers Welfare and the Minister of State for Agriculture and Farmers Welfare and appeal by Director General, ICAR to use Hindi the maximum in their official work. Under the Cash Award Scheme of Official Language, 10 personnel were given cash awards for doing their maximum work in Hindi during 2021-22. The Council also implements three more awards at its own -*Rajarshi Tandon Rajbhasha Purskar Yojana, Ganesh Shankar Vidyarthi Hindi Patrika Purskar Yojana* and *Dr Rajendra Prasad Puraskar Yojana.* As per the instructions/orders of Ministry of Home Affairs, 38 Institutes (one-third of total) were inspected for assessing the progress of Hindi and suggestions were given to rectify the shortcomings observed. This also includes inspections of Parliamentary Committee on Official Language. Besides, all Parliamentary Matters, Annual Reports, Parliamentary Committee, Annual General body Meetings of ICAR Society, and their proceedings were prepared bilingually.

The Technical Coordination Unit prepared monthly Cabinet Summary for Cabinet Secretary; organized 'Standing Committee' meeting for grant of financial assistance to scientific societies and academic for organizing seminars/symposia/ conferences and publication of Journals; organized Directors' Conference/prepared ATR and Agenda items; Coordinated and organized the ICAR Regional Committee Meetings; Collaborated with Department of Science and Technology, Bureau of Indian Standards etc.; Dealt with the references received from Prime Minister's Office, President Secretariat etc.; Laying of ICAR Annual Report, Annual Accounts and Audited Report of ICAR in both the Houses of Parliament; acted as Nodal Point for e- Samiksha portal for DARE/ICAR and Releasing funds for Swachchta Action Plan (SAP); Quarterly Reports on SAP Portal. Various ICAR Awards for 15 different categories were given to 94 awardees, comprising of 71 scientists (including 7 women) and 11 farmers (including 2 women farmers).

Training and Capacity Building: Fifteen specialized online/offline training programmes, viz. Training Workshop for Vigilance Officers of ICAR Institutes; MDP on PME in Agricultural Research Projects, MDP for Effective Implementation of Training Functions; Good Agricultural Practices (GAPs) for Higher Productivity, Profitability and Resource-use Efficiency; Appropriate Sampling Techniques Including Sample Preparation and Preservation for Soil, Water, Plant and Air Samples for Various Analyses; Experimental Data Analysis; Cyber Security; Statistical Techniques for Agricultural Data Analysis; E-governance Application in ICAR; Pension and Retirement Benefits; Capacity Building Programme Towards a Secure and Resilient Workplace at ICAR; Accrual Accounting; Assets Management; Repair and Maintenance of Office, Residential Building including Guest Houses and Establishment Matters for UDCs and LDCs were organized by 8 Competent ICAR-Institutes. In these programmes, 794 employees of various categories as per programme participated. An online Training Programme on "Living Heartfulness: Heartfulness Practices for Well-being and Harmony" was organized by HRM Unit, ICAR HQs with the support of Heartfulness Institute, Telangana in which about 35Officers/officials of ICAR HQs participated.

During the reporting period, 1,467, 621, 507 and 239 scientists, technical, administrative including finance, and SSS were trained, respectively. Compared to 2013-14, ICAR-Institutes organized 19.4 and 640.0% more training programmes for technical and skilled support staff, respectively during 2021-22. ICAR published hundred new Training Modules for all four categories of employees, i.e. Scientific, Technical, Administrative and SSS, designed, developed and organized from 2015-2020 based on TNA have been documented and published. ICAR also nominated 734 employees of various categories in training and capacity building programmes organized by various ICAR/non ICAR-Institutes, out of which 492 employees attended the training programmes.

Publications and Social Media: ICAR-DKMA encourages ICT-driven technology and create information dissemination systems to serve as agricultural knowledge repository.*The Indian Journal of Agricultural Sciences* (IJAgS) and *Indian Journal of Animal Sciences* (IJAnS) are multi-disciplinary journals, with the impact factor and H index 0.37 and 29 and 0.31 and 23, respectively. These journals had wide readership and subscription. A total of 3,500 submissions in IJAgS and 1,928 in IJAnS were received during 2022. Popular periodicals like *Indian Farming* and *Indian Horticulture* were brought out for outreach to the masses with special issues on Farmer FIRST Success Stories, Reimagining Rainfed Agro-ecosystems and International Year of Millets and Plantation Crops. Digital Object Identifier (DOI) allotment to the articles for both the research journals was introduced which will benefit the authors as well as journal immensely. To check the plagiarism, software iThenticate was subscribed. For facilitating publication of the books e-book platform was developed. During the year, ten new titles were published under the books, Stingless

Bees – An Unexplored Pollinator in India; Textbook of Ergonomics and Safety in Agriculture; Textbook on Forages; Ravine Land Management : Principles, Practices and Strategies; Textbook of Pet Animal Management; Textbook of Fundamentals of Agricultural and Animal Husbandry Extension; Textbook on Physical Chemistry and Mineralogy of soils; Textbook of Principles and Practices of Weed Management; Textbook of Environmental Agrometeorology; Sugarcane Crop Management Practices in India.

The Hindi journals *Kheti* (monthly) and *Phalphul* (bimonthly) are published to disseminate the latest technologies. These journals are circulated offline and online. During the year, six special issues of *Kheti, viz.,* 'success stories of farmers', 'livestock', 'climate change and agriculture', '75th year of publication of 'Kheti', 'Nutrition'and 'Millets' were published. The two special issues of '*Phalphul*, on Fruits, and vegetables were also published. To add the publication of the Hindi journals, e-patrika portal has been developed. The gross revenue of approximately Rs 62.0 lakhs was realized from sale of publications during the period.

To disseminate information in real-time, the ICAR Website is updated on a regular basis. Total 4,250 pages were updated and 51,89,432-page views from more than 200 countries were recorded. ICAR Twitter Handle has more than 1,94,458 Followers. On an average, 3 tweets are posted every day and a total of 1,020 tweets were posted during the year.

Administration and Finance: During the year, following posts were filled up under the promotion quota: 6 Joint Secretary/Joint Director (Admin), 3 Joint Secretary (Finance)/Senior Comptroller, 8 Director/ CAO (Senior Grade), 4 Director (F)/Comptroller, 1 Director (Official Language), 15 Deputy Secretary/CAO, 1 Deputy Director (Finance), 3 Joint Director (OL), 2 Senior Principal Private Secretary, 5 Under Secretary, 1 Senior Administrative Officer, 5 Senior Finance and Account Officer, 48 Principal Private Secretary, 6 Deputy Director (OL), 43 Administrative Officer, 17 Finance and Accounts Officer, 13 Section Officer, 11 Private Secretary and 22 Assistants at ICAR Headquarters. During the year, 10 eligible officers and Staff of ICAR were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme.The RE of DARE/ ICAR for 2021-22 was ₹ 8,513.62 crores. An internal resource of ₹ 352.2 crores (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2021-22. The total BE for 2022-23 is ₹ 8,513.62 crores.

ICAR, for its services to nation and contribution towards furtherance of science, has won several accolades in the past, viz Global Gene Stewardship Award 2018 of the Borlaug Global Rust Initiative; International King Bhomibol Word Soil Day Award of FAO, 2020; and Digital India Awards 2020. ICAR is working concomitantly with other national and international organizations in the field of agriculture. The ICAR Annual Report 2022-23 will provide updated information on research, education and extension technologies and innovations to address the challenges of Indian agriculture. I sincerely hope that the Annual Report will be useful for researchers, policy makers, development functionaries, farmers, farm-women and students and help in promoting research and development.

(Himanshu Pathak)

Secretary, Department of Agricultural Research & Education

and Director General, Indian Council of Agricultural Research, New Delhi

2. Crop Improvement

Crop Varieties Released and Notified

Since 1965, 5,967 improved field crops varieties have been developed which include 2,943 of cereals, 975 of oilseeds, 1,083 of pulses, 233 of forage crops, 538 of fiber crops, 146 of sugarcane and 49 of potential crops. During 2021–22, a total of 467 varieties/hybrids including 35 special traits varieties (23 varieties developed through marker assisted selection and 12 biofortified varieties) were notified and released for commercial cultivation. Details are given below:

Cereals: Two hundred and eighteen high yielding varieties/hybrids of cereals comprising 125 of rice, 30 of maize, 21 of wheat, 13 of sorghum, 12 of pearl millet, 7 of finger millet, 5 of kodo millet, 2 each of barley and little millet and 1 of barnyard millet were released for cultivation in different agro-ecologies of the country.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Salient features
Rice (*Oryza sativa*)		
Sahyadri Panchmukhi	Karnataka	Suitable for lowland situation in *kharif* season, yield 50–55 q/ha, maturity 130–135 days, tolerant to leaf and neck blast apart from tolerance to major insect-pests, stem-borer, gall midge and leaf folder.
Sahyadri Megha	Karnataka	Suitable for *kharif* condition in delayed onset of monsoon, yield 65.0 q/ha, maturity 120 days, a red variety of paddy with high protein (12.48%) and high nutrients, resistant to blast.
DRR Dhan 57	Jharkhand and Chhattisgarh	Suitable for water-limited direct-seeded aerobic condition, yield 47.8 q/ha, maturity 113–120 days, short bold grained variety, resistant to gall midge, rice thrips and moderately resistant to leaf blast, neck blast, plant-hoppers and whorl maggot.
DRR Dhan 58 (IET 28784)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Jharkhand, Odisha, Chhattisgarh, Maharashtra, Gujarat and Bihar	Suitable for *kharif* season in salinity prone and bacterial blight endemic areas, yield 41.5 q/ha (in normal condition) and 28.4 q/ha (in coastal salinity stress condition), maturity 130–135 days, tolerant to salinity and resistant to bacterial blight (*Saltol*, *Xa21*, *xa13* and *xa5* genes introgressed in the genetic background of improved Samba Mahsuri).
DRR Dhan 59 (IET 27280)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Jharkhand	Suitable for irrigated, medium ecology condition, yield 55.0 q/ha, maturity 125–130 days, MAS derived, bacterial blight resistant (having bacterial blight resistance gene *Xa33*).
DRR Dhan 60 (IET 28061)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Jharkhand, Odisha, Chhattisgarh, Maharashtra, Gujarat and Bihar	Suitable for medium–low soil phosphorous regions and bacterial blight endemic areas, yield 39.7 q/ha under normal conditions and 37.64 q/ha under stress prone conditions, maturity 125–130 days and resistant to bacterial blight.
DRR Dhan 62 (IET 28804)	Telangana, Andhra Pradesh, Tamil Nadu, Karnataka, Chhattisgarh, Odisha, Jharkhand, Bihar, Gujarat and Maharashtra	Suitable for irrigated, transplanted condition, yield 42.3 q/ha, maturity 135–140 days, semi-dwarf, non-lodging, resistant to leaf blast, BLB, neck blast, brown spot and sheath-rot.
Pusa Basmati 1847 (IET 27722)	Delhi, Punjab and Western Uttar Pradesh	Suitable for irrigated, transplanted condition of Basmati GI areas of northwest India, yield 57.0 q/ha, maturity 115–120 days, resistant to bacterial leaf blight and blast diseases.
Pusa Basmati 1885 (IET 28807)	Delhi, Punjab and Haryana	Suitable for irrigated, transplanted condition, yield 47.0 q/ha, maturity 134–139 days, resistant to bacterial blight disease.
Pusa Basmati 1886 (IET 28808)	Haryana and Uttarakhand	Suitable for irrigated, transplanted condition, yield 44.9 q/ha, maturity 135–140 days, resistant to bacterial leaf blight and blast diseases.
Pusa Basmati 1979 (IET 28812)	Delhi, Punjab and Haryana	Suitable for irrigated, transplanted condition, yield 45.8 q/ha, maturity 130–133 days and herbicide tolerance.

Variety	Area of adoption	Salient features
Pusa Basmati 1985 (IET 28814)	Delhi, Punjab and Western Uttar Pradesh	Suitable for irrigated, transplanted condition, yield 52.0 q/ha, maturity 115–120 days and herbicide tolerance.
NPH-XI (IET 27332)	Jharkhand and West Bengal	Suitable for irrigated, transplanted condition, yield 63.5 q/ha, maturity 117 days, moderately resistant to sheath-rot, false smut, BPH and gall midge.
MR 8666	Odisha, Uttar Pradesh, Chhattisgarh and Andhra Pradesh	Suitable for irrigated, condition, yield 70 q/ha, maturity 140 days, medium slender grains, moderately resistant to leaf blast, neck blast and BPH.
Swarna Unnat Dhan (IET 27892)	Odisha, Bihar, West Bengal, Madhya Pradesh and Maharashtra	Suitable for irrigated, transplanted condition, under natural screening yield 53.0 q/ha, maturity 115–120 days, moderately resistant to bacterial leaf blight, sheath-rot, leaf blast and brown spot, BPH, stemborer and gall midge.
MTU 1281	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Puducherry and Odisha	Suitable for irrigated, condition, yield 70.0 q/ha, maturity 140 days, non-lodging, low grain shattering, medium slender grain, moderately resistant to leaf blast, neck blast and BPH.
CR Dhan 320 (IET 27914)	Bihar, Jharkhand and West Bengal	Suitable for early irrigated, condition, yield 65.8 q/ha, maturity 84–88 days, vigorous, non-lodging, non-shattering, long slender grain, moderately resistant to leaf blast, brown spot, sheath-rot, moderately tolerant to BPH, LF and stem-borer.
CR Dhan 318 (IET 27803)	Bihar, West Bengal, Uttarakhand and Haryana	Suitable for irrigated, condition, yield 54–60 q/ha, maturity 118–120 days, moderately resistant to false smut, neck blast, leaf blast, highly tolerant to leaf folder, stemborer (dead heart), and whorl maggot insect-pests, moderately tolerant to gall midge (Biotype 1) and stemborer (white ear heads).
CR Dhan 319	Bihar and Odisha	Suitable for irrigated, areas, rainfed medium land and for dry Boro/dalua season, yield 60.3 q/ha, maturity 130–135 days, good hulling, milling, HRR and amylose content, resistant to false smut, tolerant to stem-borer (both DH and WEH) and moderately tolerant to BPH.
DRR Dhan 63 (IET 26383)	Uttar Pradesh, Odisha and Kerala	Suitable for timely-sown condition, yield 60.5 q/ha, maturity 127–130 days, semi-dwarf, non-lodging, non-shattering, moderately resistant to leaf blast and BLB.
VL Dhan 69 (IET 26596)	Uttarakhand, Sikkim, and Jammu and Kashmir	Suitable for irrigated, condition, yield 42.6 q/ha, maturity 125–130 days, moderately resistant to leaf blast, neck blast, brown spot and sheath-rot, BPH, WBPH, stemborer and grasshopper.
Telangana Vari 4	Bihar, Jharkhand and Odisha	Suitable for early irrigated, condition in both *kharif* and *rabi* seasons, yield 55.9 q/ha, maturity 116 days, long slender grains, moderately resistant to neck blast and rice tungro virus.
MTU 1212 (IET 26819)	Andhra Pradesh and Telangana	Suitable for irrigated, transplanted condition, yield 79.7 q/ha, maturity 140 days, moderately resistant to leaf blast, neck blast, sheathblight, sheath-rot and BLB.
MTU 1280	Andhra Pradesh, Telangana, Tamil Nadu and Karnataka	Suitable for the irrigated, wetland ecosystem, yield 60.7 q/ha, maturity 135 days, non-lodging, low grain shattering with fertilizer responsiveness, moderately resistant to neck blast, rice tungro disease, stemborer and leaf folder.
Kalinga Dhan 1201	Chhattisgarh, Maharashtra and Odisha	Suitable for irrigated, mid-early ecology, yield 57.2 q/ha, maturity 123–130 days, moderately resistant to stem-borer, leaf folder, gall midge, blast and BLB.
Kalinga Dhan 1202	Chhattisgarh, Maharashtra and Odisha	Suitable for irrigated, late conditions, yield 60.5 q/ha, maturity 155–160 days, non-lodging, non-shattering, moderately resistant to sheath-rot, stem-borer, leaf folder and WBPH.
Kalinga Dhan 1203 (IET 27117)	Chhattisgarh, Maharashtra and Odisha	Suitable for irrigated, medium land, yield 54.3 q/ha, maturity 135 days, medium slender grain, moderately resistant to sheath-rot, BPH, stem-borer and leaf folder.
Kalinga Dhan 1301	Andhra Pradesh and Tamil Nadu	Suitable for medium land, yield 59.6 q/ha, maturity 130 days, non-lodging, non-shattering, moderately resistant to neck blast, sheath-rot, BLB, BPH, stem-borer and leaf folder.
GR 18 (Devli Kolam)	Gujarat	Suitable for early irrigating transplanted conditions, yield 56.0 q/ha, maturity 110–115 days, non-lodging, moderately resistant against leaf blast, grain discoloration, sheath-rot, moderately tolerant against white-backed plant-hopper, stem-borer and sheath mite.

Variety	Area of adoption	Salient features
GR 19 (Auranga)	Gujarat	Suitable for transplanted rice growing salt affected areas of Gujarat, yield 53.0 q/ha, maturity 125–130 days, salt-tolerant, moderately resistant against bacterial leaf blight, grain discoloration, sheath-rot, tolerant to brown plant-hopper, moderately resistant against stem-borer, leaf folder and sheath mite.
GNR-8 (Aarti)	Gujarat	Suitable for aerobic early condition, yield 51.7 q/ha, duration 110–115 days, moderately resistant against bacterial leaf blight, grain discoloration, sheath-rot, stem-borer, leaf folder, sheath mite and tolerant against brown plant-hopper.
JR 10	Madhya Pradesh	Suitable for the irrigated, early duration, yield 55.0 q/ha, maturity 120 days, long slender grains and resistant to blast.
CO 54 (CB 12588)	Tamil Nadu	Suitable for irrigated, condition, yield 63.54 q/ha, maturity 115–118 days, moderately resistant to blast, sheath-rot, brown spot and BPH.
ADT 55	Tamil Nadu	Suitable for irrigated, wet condition, yield 59.3 q/ha, maturity 115 days, MAS derived variety, medium slender grains, resistant to bacterial blight (having *xa5*, *xa13* and *Xa21* genes), moderately resistant to blast, sheath-rot and leaf folder.
Rice TRY 4 (TR 05031)	Tamil Nadu	Suitable for irrigated, condition, yield 57.3 q/ha, maturity 127 days, medium slender grains, tolerant to sodicity/salinity, resistant to leaf folder, stem-borer, gall midge, blast and brown spot.
Trombay Chhattisgarh Sonagathi Mutant (TCSM)	Chhattisgarh	Suitable for irrigated, and rainfed conditions, yield 60–65 q/ha, maturity 135–140 days, moderately resistant against leaf blast, brown spot, sheath blight, stem-borer and leaf folder.
Trombay Chhattisgarh Vishnubhog Mutant (TCVM)	Chhattisgarh	Suitable for irrigated, and rainfed conditions, yield 40–45 q/ha, maturity 120–125 days, moderately resistant to leaf blast, neck blast, sheath blight and brown spot.
PR 128 (RYT 3437)	Punjab	Suitable for timely-sown and irrigated, conditions, yield 77.1 q/ha, maturity 143 days, resistant to all the 10 pathotypes of *Xanthomonas oryzae* pv. *Oryzae* (causal organism of bacterial blight) prevalent in Punjab.
PR 129 (RYT 3468)	Punjab	Suitable for timely-sown and irrigated, conditions, yield 73.9 q/ha, maturity 140 days, resistant to all the 10 pathotypes of *Xanthomonas oryzae* pv. *Oryzae* (causal organism of bacterial blight) prevalent in Punjab.
Swarna Sukha Dhan (IET 24692)	Uttar Pradesh	Suitable for cultivation in drought prone rainfed mid-land to upland ecosystem, yield 35.8 q/ha (normal) and 28.3 q/ha (under moderate drought conditions), maturity 110–115 days, semi-dwarf, medium slender grains, multistage drought tolerant, resistant to lodging and shattering, moderately resistant to leaf blast, bacterial leaf blight, brown spot, sheath blight, RTD, glume discoloration, false smut and moderately resistant to stem-borer, leaf folder, BPH, and whorl maggot.
Chhattisgarh Dhan 1919	Chhattisgarh	Suitable for rainfed and irrigated, conditions, yield 55–60 q/ha, maturity 130–135 days, resistant to gall midge, tolerant to neck blast and brown spot.
CR Dhan 702 (IET 25231)	Odisha	Suitable for irrigated, and rainfed shallow lowland, yield 70–75 q/ha (*kharif*) and 75–80 q/ha (*rabi*), maturity 140–145 days, low light insensitive variety, sustain 10–15 days submergence at seedling stage, resistant to false smut, moderately resistant to BLB, leaf blast, neck blast, tolerant to gall midge, BPH and WBPH.
CR Dhan 703 (IET 25278)	Odisha	Suitable for boro and rainfed shallow lowland, yield 70–75 q/ha (*kharif*) and 75–80 q/ha (*rabi*), maturity 140–145 days, low light insensitive variety, sustain 10–15 days submergence at seedling stage, tolerant to cold at seedling stage, resistant to false smut, moderately resistant to BLB, RTD and field tolerant to gall midge, BPH and WBPH.
CR Dhan 316 (CRRI Gaurav-1)	Odisha	Suitable for irrigated, medium land, yield 72.0 q/ha, maturity 130–135 days, resistant to stem-borer, moderately resistant to leaf folder, tolerant to major diseases and pests.
CR Dhan 317 (Roshan)	Odisha	Suitable for irrigated, medium land, yield 50.1 q/ha, maturity 135–140 days, resistant to BPH, tolerant to leaf folder, gundhi bug and WBPH.

Variety	Area of adoption	Salient features
CR Dhan 411 (Swaranjali, IET 27852)	Odisha	Suitable for irrigated,/rainfed shallow low-land, yield 56.2 q/ha, maturity 140 days, biofortified rice variety with short bold grain, protein 10.01% and protein yield 5.29 q/ha (29% and 31% higher than variety Swarna, respectively), resistant to leaf folder, moderately resistant to stem-borer, moderately tolerant to leaf blast, brown spot and BLB.
CR Dhan 412 (NICRA Dhan, Luna Ambika)	Odisha	Suitable for coastal saline areas, yield 43.8 q/ha, maturity 140 days, tolerant to salinity stresses and stagnant flooding, non-lodging, resistant to leaf folder, moderately resistant to stem-borer, tolerant to BLB and moderately tolerant to sheath-rot.
CR Dhan 413 (Reeta-Panidhan)	Odisha	Suitable for rainfed shallow lowlands, yield 59.76 q/ha, maturity 145–150 days, submergence and flash flood tolerant, resistant to BPH, WBP, stem-borer (dead heart), moderately resistant to white ear head, leaf plant-hopper, leaf folder and case worm.
CR Dhan 512 (Satrughan)	Odisha	Suitable for semi-deep water ecology, yield 39.23 q/ha, maturity 150–155 days, tolerant to water-logging and submergence, moderately tolerant to leaf blast, neck blast, sheath blight and bacterial blight disease, resistant to whorl maggot and rice thrips, moderately resistant to stem-borer (dead heart), and white ear head.
CR Dhan 803 (Trilochan, IET 26398)	Odisha	Suitable for rainfed shallow lowland ecology, yield 50.4 q/ha (normal) and 34.5 q/ha (under submergence), maturity 150 days, tolerant to submergence, resistant to stem-borer (dead heart), BPH, moderately resistant to white ear head, WBPH, leaf folder, plant-hopper, case worm, neck blast, and rice tungro virus.
CSR 76 (IET 27070)	Uttar Pradesh	Suitable for irrigated, and sodic soils, yield 45.3 q/ha, maturity 125–130 days, white long slender grains, tolerant to sodicity, moderately resistant to leaf and neck blast, bacterial leaf blight, moderately tolerant to hoppers (brown and green), gall midge, and case worm.
PDKV Sakoli Red Rice 1	Maharashtra	Suitable for transplanted condition during *kharif* season, yield 43.0 q/ha, maturity 137 days, contains iron 15.97 µg/g and zinc 23.19 µg/g (in grain dry weight of unpolished rice), moderately resistant to leaf blast, leaf scalds, and stem-borer.
Rajendranagar Vari 1 (RNR-11718) (IET 27077)	Telangana, Karnataka and Puducherry	Suitable for medium duration, inland salinity prone areas, yield 66.4 q/ha, maturity 135–140 days, salinity tolerant, moderately resistant to leaf and neck blast, BLB, brown spot, BPH, stem-borer, and leaf folder.
Rajendranagar Vari 2 (IET 26143)	Telangana	Suitable for medium duration *kharif* cultivation, yield 51.0 q/ha, maturity 135–140 days, aromatic long grain, moderately resistant to blast and brown spot.
Warangal Vari 2 (WGL-962) (IET 26094)	Telangana	Suitable for irrigated, ecology, yield 65–75 q/ha, maturity 125 days, moderately resistant to leaf and neck blast and tolerant to stem-borer.
Kunaram Vari 2 (KNM 1638) (IET No. 26245)	Telangana	Suitable for irrigated, ecology, yield 76–85 q/ha, maturity 120–125 days (*kharif*), 130–135 days *rabi*), resistant to gall midge biotype 1, 3 and 4, leaf blast and moderately resistant to neck blast.
Kampasagar Vari 1 (IET 27816)	Telangana	Suitable for *kharif* season, yield 63.9 q/ha, maturity 135–140 days, tolerant to salinity stress, moderately resistant to leaf blast and neck blast, and tolerant to BPH.
VL Dhan 210 (VL 11364)	Uttarakhand	Suitable for spring sown, rainfed, upland organic condition, yield 21.6 q/ha, maturity 140–150 days, resistant to leaf blast, neck blast, brown spot, stem-borer and leaf folder.
VL Dhan 211 (VL 11574)	Uttarakhand	Suitable for spring sown, rainfed, upland organic condition, yield 20.9 q/ha, maturity 140–150 days, resistant to leaf blast, neck blast, brown spot, stem-borer and leaf folder.
Kalinga Dhan- 1401	Odisha	Suitable for irrigated, ecology, yield 76.9 q/ha, maturity 120–125 days (*kharif*) and 130–135 days (*rabi*), resistant to gall midge biotype 1, 3 and 4, leaf blast, and moderately resistant to neck blast.
Kalinga Dhan 1501 (IET 24496)	Odisha	Suitable for semi-deep water, yield 42.8 q/ha, maturity 155 days, moderately resistant to neck blast, sheath-rot, bacterial blight, grain discolouration and gall midge.

Variety	Area of adoption	Salient features
Kalinga Dhan 1502 (IET 25212)	Odisha	Suitable for semi-deep water low-land, yield 47.1 q/ha, maturity 155 days, moderately resistant to neck blast, sheath blight, sheath-rot, BLB, false smut and leaf folder.
Kalinga Dhan 1204 (IET 25620)	Odisha	Suitable for aerobic and irrigated, medium land, yield 43.2 q/ha, maturity 125 days, moderately resistant to sheath-rot, BLB, stem-borer and leaf folder.
Karjat Shatabdi (BM-4) (IET 27796)	Maharashtra	Suitable for scented beaten rice (Poha), yield 39.4 q/ha, maturity 125–130 days, non-lodging, dwarf, mutant variety of 'Botvel', a beaten rice local cultivar, short bold grain, moderately resistant to stem-borer, bacterial leaf blight and leaf blast.
Jal Bhawani (NDGR 702) (IET 25882)	Uttar Pradesh	Suitable for rainfed low-land condition, yield 35–40 q/ha, maturity 140–145 days, medium resistance to grain shattering and moderately resistant to neck blast, stem-borer.
Sikkim Dhan 1 (IET 22984)	Sikkim	Suitable for both rainfed, upland and irrigated, organic conditions, yield 35.0 q/ha (upland), 45.0 q/ha (irrigated, transplanted conditions), maturity 135 days, resistant to leaf and neck blast, moderately resistant to sheath blight, bacterial leaf blight and brown spot.
Sikkim Dhan 2 (IET 26579)	Sikkim	Suitable for irrigated, organic and rainfed upland conditions, yield 29.3 q/ha, maturity 134 days, moderately resistant to leaf blast, resistant to sheath-rot, brown spot, sheath blight and false smut, tolerant to prevalent pests in Sikkim, viz. leaf folder, stem-borer and gundhi bug.
Sikkim Dhan 3 (IET 25539)	Sikkim	Suitable for irrigated, condition, yield 55–60 q/ha, maturity 125–130 days, moderately resistant to BLB, neck blast, sheath-rot
CG Tejaswi Dhan (IGKV DH Rice-1) (IET- 28452)	Chhattisgarh	Suitable for irrigated, ecosystem, yield 58.0–60.0 q/ha, maturity 125–130 days, semi-dwarf, moderately resistant to BLB, neck blast and sheath-rot.
Kalinga Dhan 1205 (IET 22579)	Odisha	Suitable for rainfed upland, yield 29.3 q/ha, maturity 134 days, resistant to leaf blast, sheath-rot, brown spot, tolerant to leaf folder, gundhi bug and stem-borer.
Sava 300	Madhya Pradesh	Suitable for irrigated, early stress condition, yield 64.4 q/ha, maturity 115–120 days, tolerant to drought, lodging tolerant, long slender grain, tolerant to blast, rice bunt, BPH and GLH.
Sava 200	Madhya Pradesh	Suitable for early rainfed and irrigated, ecology, yield 76.5 q/ha, maturity 100–110 days, tolerant to drought, leaf blight, blast, sheath blight, rice tungro virus and stem-borer.
ADT 56 [IET 27920 (AD 16028)]	Chhattisgarh, Maharashtra, Madhya Pradesh, Bihar, Jharkhand and West Bengal	Suitable for irrigated, transplanted and direct seeded conditions, yield 52.2 q/ha, maturity 118–120 days, high milling (69.4%) and head rice yield (58.8%), moderately resistant to leaf blast, grain discolouration, RTD, stem-borer and leaf folder.
AZ 8433 DT HRI-202 (IET 28160)	Haryana, Punjab, Uttar Pradesh, Bihar, Jharkhand, Odisha, Madhya Pradesh, Chhattisgarh, Telangana, Andhra Pradesh, Tamil Nadu and Karnataka	Suitable for *kharif* irrigated, lowland for both high and low fertility conditions, yield 67.2 q/ha, maturity 130–135 days, resistant to BLB and BPH.
CR Dhan 321 (IET 28354)	Odisha, Bihar, Jharkhand, West Bengal, Uttar Pradesh, Tripura, Assam, Chhattisgarh and Maharashtra	Suitable for early-sown irrigated, ecology, yield 54.5 q/ha, maturity 118–120 days, non-lodging, intermediate grain shattering, fertilizer responsive, moderately resistant to false smut, neck blast, leaf blast, brown spot, grain discoloration and high field tolerance for sheath-rot.
CR Dhan 314 (IET 27263)	Odisha and Bihar	Suitable for irrigated, *kharif* ecology, yield 6.63 tonnes/ha, maturity 130–135 days, highly resistant to false smut, leaf folder, moderately resistant to stem-borer (dead heart).
CR Dhan 414 (IET 27051)	Coastal areas of Odisha, West Bengal and Andhra Pradesh	Suitable for coastal saline ecology, yield 42.2 q/ha, maturity 145–150 days, tolerant to salinity, osmotic stress, stagnant flooding and ability for anaerobic germination, resistant to leaf folder, moderately resistant to stem-borer, neck blast and rice tungro virus.

Variety	Area of adoption	Salient features
ICAR NEH NICRA-BoroDhan 1 (TRC 2016-14) (IET 26435)	Tripura, Assam and West Bengal	Suitable for boro season aerobic condition, yield 64.4 q/ha, maturity 145 days, long slender grains, head rice recovery 65.15%, moderately resistant to leaf blast, neck blast and bacterial leaf blight.
ICAR-NEH NICRA Hill Rice 2022-2 (TRC PSM-1720-B-B-5-1) (IET 28230)	Himachal Pradesh and Manipur	Suitable for rainfed upland hills, yield 30.6 q/ha, maturity 120–125 days, tolerant to moisture stress and perform well under moderate drought stress, short bold grains with head rice recovery of 61.6%, and moderately tolerant to neck blast.
KKL (R) 2 (IET 28791)	Tamil Nadu and Puducherry	Suitable for irrigated, submergence prone ecosystem, yield 36.0 q/ha, maturity 137 days, MAS variety with introgressed *sub1* gene, tolerant against flash flooding/submergence up to 2 weeks and moderately resistant to RTD, and leaf spots.
Telangana rice 5 (RNR 28362) (IET 28746)	Uttar Pradesh and Odisha	Suitable for irrigated, *kharif* ecosystem, yield 53.2 q/ha, maturity 130–135 days, moderately resistant to leaf blast, neck blast, brown spot, sheath-rot and grain discoloration.
Telangana Rice 6 [KNM 7048 (IET 28332)]	Odisha, West Bengal, Chhattisgarh and Maharashtra	Suitable for irrigated, early condition, yield 57.3 q/ha, maturity 115–120 days, moderately resistant to leaf blast and sheath-rot.
Telangana Rice 7 [KNM 6965 (IET 28343)]	Chhattisgarh and Maharashtra	Suitable for early, intensive irrigated, *kharif* ecosystem, yield 49.2 q/ha, maturity 115–120 days, moderately resistant to leaf blast and grain discoloration, non-lodging, and low shattering.
WGL-1487 (Telangana Vari-8) (IET 28818)	Andhra Pradesh and Telangana	Suitable for irrigated, and rainfed shallow low-land, yield 44.5 q/ha, maturity 125–130 days, MAS variety, shows consistent superiority under low soil p stress, having introgressed Pup 1 QTL, moderately resistant to leaf blast and neck blast and resistant to brown plant-hopper.
DRR Dhan 64 (IET 28358)	Bihar and West Bengal	Suitable for irrigated, early, transplanted ecosystem, yield 53.3 q/ha, maturity 115–120 days, moderately resistant to leaf blast, neck blast, plant-hoppers, whorl maggot and resistant to gall midge, and rice thrips.
DRR Dhan 65 (IET 27641)	Telangana, Andhra Pradesh, Karnataka, Chhattisgarh, Jharkhand and Maharashtra	Suitable for irrigated, and rainfed shallow low-land, yield 60.1 q/ha, maturity 130–135 days, shows consistent superiority under low soil p stress, tolerant to leaf blast, neck blast, plant-hoppers and stem-borer.
DRR Dhan 66 (IET 28066)	Andhra Pradesh and Telangana	Suitable for both *kharif* and *rabi* ecosystem in irrigated, and upland rice growing regions with low soil P, yield 50.3 q/ha, maturity 120–125 days, shows consistent superiority under low soil P stress, and moderately resistant to leaf blast.
DRR Dhan 67 (BRRI Dhan 84)	Assam, West Bengal and Tripura	Suitable for boro, clay loam to loam and irrigated, ecosystem, yield 65.7 q/ha, maturity 140–145 days, high zinc (27.6 mg/kg) variety, moderately resistant to bacterial leaf blight and WBPH.
DRR Dhan 68 (BRRI Dhan 99)	Assam, West Bengal and Tripura	Suitable for boro, clay loam to loam and irrigated, ecosystem, yield 63.6 q/ha, maturity 145–157 days, moderately resistant to bacterial leaf blight.
DRR Dhan 69 (BRRI Dhan 100)	Assam, West Bengal and Tripura	Suitable for boro, clay loam to loam and irrigated, ecosystem, yield 55.0 q/ha, maturity 148 days, high zinc (25.7 mg/kg) variety, moderately resistant to bacterial leaf blight, sheath blight and relatively low incidence of diseases and pests in BRRI Dhan 100.
Sabour Heera Dhan (IET 27538) (BRR 211)	Karnataka and Andhra Pradesh	Suitable for rainfed shallow lowland ecosystem, yield 45.9 q/ha, maturity 145–150 days, moderately resistant against gloom discoloration, brown spot, blast, bacterial leaf blight and sheath blight.
DRRH 4 (IET 27937)	Punjab, Odisha, Chhattisgarh, Tripura and Gujarat	Suitable for rice growing regions with direct seeded aerobic condition, yield 50.3 q/ha, maturity 113–120 days, respond to higher doses of nitrogen and moderately resistant to leaf blast, neck blast, gall midge, rice stem-borer, and whorl maggot.
Pusa Basmati 1882 (IET 28788)	Western Uttar Pradesh, National Capital Region of Delhi, Uttarakhand, Haryana, Punjab and Jammu and Kashmir	Suitable for irrigated,/limited irrigated, *kharif* ecosystem with high fertility conditions, yield 4.5–5.0 tonnes/ha, maturity 134 days, MAS variety having drought tolerant qDTY1.1 QTL and tolerant to drought stress.

Variety	Area of adoption	Salient features
Pusa Samba 1853 (IET 28014)	Andhra Pradesh and Telangana	Suitable for irrigated, *kharif*, high fertility condition, yield 39.8 q/ha, maturity 140–145 days, MAS derived basmati rice variety with bacterial leaf blight resistant genes (*Xa21+xa13*) and blast resistant genes (*Pi54+Pi1+Pita*) have been introgressed.
Swarna Purvi Dhan 3 (IET 28329)	Haryana, Rajasthan, Bihar, Uttar Pradesh, Chhattisgarh and Maharashtra	Suitable for direct seeded, aerobic, irrigated, *kharif* ecology, yield 50–55 q/ha, maturity 115–120 days, tolerant to medium to severe multi-stages drought stress, moderately resistant to BLBs, leaf blast, neck blast, sheath blight, brown spot, false smut, sheath-rot and glume discoloration diseases, and BPH, stem-borer, leaf folder and biotype insect-pest, high head rice recovery (64.7%).
MTU Rice 1273	Chhattisgarh, Maharashtra and Gujarat	Suitable for irrigated, wetlands, yield 53.1 q/ha, maturity 117–120 days, moderately resistant to leaf blast and rice brown spot disease.
MTU Rice 1293	Andhra Pradesh and Telangana	Suitable for coastal saline lands, yield 59.4 q/ha, maturity 117–120 days, tolerant to salinity, moderately resistant to leaf blast, sheath-rot, rice tungro virus and brown spot diseases, and translucent kernels with high head rice recovery (66%).
MTU Rice 1310	Andhra Pradesh, Telangana, Tamil Nadu and Karnataka	Suitable for irrigated, wetlands, yield 75.0 q/ha, maturity 135–140 days, moderately resistant to neck blast, rice tungro disease, stem-borer, leaf folder and leaf blast, and translucent kernels with head rice recovery of 55%.
MTU Rice 1321	Telangana, Tamil Nadu, Karnataka and Puducherry	Suitable for irrigated, wetlands, yield 69.5 q/ha, maturity 135–140 days, moderately resistant to leaf blast, neck blast, sheath blight, sheath-rot and rice tungro disease.
Uttar Samir (PUR-B36(IET 26453)	West Bengal	Suitable for irrigated, medium land or upland during boro season, yield 58.9 q/ha, maturity 145–150 days, resistant to panicle blast, leaf blast, sheath-rot, bacterial leaf blight, rice tungro disease and sheath blight.
Uttar Sugandhi (UBKVRA 2 (IET 24616)	West Bengal	Suitable for rainfed, low-land and medium land situations, yield 40.4 q/ha, maturity 150 days, tolerant to terminal drought, resistant to PB, SR, BLB, RTD and SB diseases.
Gujarat Rice 20 (Navsari Kamod) [IET 27797]	Gujarat	Suitable for transplanted irrigated, areas of Gujarat, yield 45–55 q/ha, maturity 120–125 days, moderately resistant to bacterial leaf blight, grain discoloration and sheath-rot, tolerant to brown plant-hopper, stem-borer, leaf folder and sheath mite, and strong aroma with short slender grain.
Gujarat Rice 21 (GR Vatrak)	Gujarat	Suitable for transplanted irrigated, areas, yield 50–55 q/ha, maturity 120–130 days, moderately resistant to white-backed plant-hopper, yellow stem-borer, leaf folder and bacterial leaf blight, leaf blast, neck blast, sheath-rot and grain discoloration, good milling and cooking quality, unpolished rice contains higher Zn and Fe.
Gujarat Anand Rice 22 (GAR Swagat)	Gujarat	Suitable for transplanted irrigated, areas of middle Gujarat, yield 50–60 q/ha, maturity 125–135 days, moderately resistant to white-backed plant-hopper, yellow stem-borer and resistant to leaf blast, neck blast, bacterial blight, sheath-rot, grain discoloration, good milling and cooking quality, kernel length after cooking 10.9 mm.
Haccha (AAU DPU Dhan 04)	Assam	Suitable for upland rainfed *ahu* (autumn) season, yield 30.7 q/ha, maturity 97–103 days, moderately resistant to leaf blast, neck blast, brown spot, sheath-rot, stem-borer, leaf folder and plant-hopper.
Langpi (AAU DPU Dhan 05)	Assam	Suitable for medium-low-land, yield 53.3 q/ha, maturity 140–145 days, rich in organic matter under rainfed situation, sali (winter) variety, resistant to sheath blight and blast, moderately resistant to gundhi bug, stem-borer and leaf folder under organic conditions.
Diyung (AAU DPU Dhan 06)	Assam	Suitable for medium-low-land rich in organic matter under rainfed sali (winter) situation, yield 62.4 q/ha, maturity 140–145 days, moderately resistant to stem-borer, gundhi bug and leaf folder.
AAU-TTB Dhan 40 (Dholi)	Assam	Suitable for rainfed condition, yield 47.2 q/ha, maturity 130–135 days, submergence tolerance up to 12 days and tolerant to stem-borer.
AAU-KMJ- Dhan-46 (Surma Dhan)	Assam	Suitable for rainfed low-land condition, yield 45.4 q/ha, maturity 145 days, possesses fair degree of submergence tolerance, highly resistant to false smut, neck blast, BLB and resistant to brown spot.

Variety	Area of adoption	Salient features
CR Dhan 415 (Kamesh) IET 22097	Jharkhand	Suitable for rainfed drought prone shallow lowlands of Jharkhand, yield 50.7 q/ha, maturity 120–125 days, tolerant to drought, resistant to blast and moderately resistant to brown spot.
CR Dhan 103 (Pramod) IET 22020	Jharkhand	Suitable for direct seeded rainfed uplands in Jharkhand, yield 35.3 q/ha, maturity 95–100 days, tolerant to drought, resistant to blast and moderately resistant to brown spot.
CR Dhan 107 (Unnat Vandana) IET 26337	Jharkhand	Suitable for drought-prone rainfed direct seeded areas of Jharkhand, yield 39.8 q/ha, maturity 90–95 days, drought tolerant, moderately resistant to brown spot, resistant to blast and tolerant to P-deficiency.
VL Dhan 70	Uttarakhand	Suitable for irrigated, transplanted organic condition of hills and valleys, yield 39.2–39.9 q/ha, maturity 125–130 days, resistant to leaf and neck blast, brown leaf spot, and grain discoloration, extra long slender kernel (length 7.60 mm).
RC Maniphou 15 (RCM 36, IET 26583)	Manipur	Suitable for valley and terraced hill condition, yield 66.2 q/ha, maturity 126–132 days, resistant to leaf and neck blast and tolerant to false smut.
RC Maniphou 16 (RCM 37, IET 27495)	Manipur	Suitable for valley and terraced hill condition, yield 70–80 q/ha, maturity 125–130 days, tolerant to leaf and neck blast.
RC Maniphou 14 (RCM 33, IET 25841)	Manipur	Suitable for rainfed valley, foothills and terraces with transplanted rice cultivated areas, yield 69.3–79.3, maturity 125–135 days, resistant to leaf blast, neck blast, brown spot and tolerant to sheath blight.
GNR-9 (Lalkada Gold)	Gujarat	Suitable for *kharif* season irrigated, transplanted condition, yield 40–45 q/ha, maturity 110–115 days, can be grown in summer season also, high protein red rice variety (8.44% protein in polished rice) and resistant to leaf blast.
BMR-MS-1-2-1	Karnataka	Suitable for *kharif* season midland situation of coastal zone, yield 50–55 q/ha, maturity 130–135 days, red rice, dwarf variety, tolerant to gall midge, leaf and neck blast, false smut, gall midge, stem-borer and gundhi bug.
Sahyadri Kempumukthi (IET 29855)	Karnataka	Suitable for southern transitional zone (command areas, viz. zone-7) and upland hill zone (zone-9) of Karnataka, yield 70–75 q/ha (zone-7) and 40–45 q/ha (zone-9), maturity 125–130 days, resistant to blast and udbatta diseases and tolerant to leaf folder, stem-borer, and corid bug.
SKUA 494 (Shalimar Sugandh 1)	Kashmir valley	Suitable for irrigated, low-land (plains basins of the valley) but not in water sub-merged areas, yield 63.8 q/ha, maturity 130–135 days, temperate basmati, tolerant to blast and other diseases.
CO 55 (CB 15714) 4 (IET 27873)	Tamil Nadu	Suitable for irrigated, transplanted and direct seeded condition, yield 60.6 q/ha, maturity 110–115 days, moderately resistant to RTD, semi-dwarf super fine, short, slender rice variety with good cooking traits and high HRR (65.0%).
Rice ADT 57 [AD 09219] (IET 25569)	Tamil Nadu	Suitable for irrigated, transplanted and direct seeded condition, yield 65 q/ha, maturity 115 days, resistant to blast, moderately resistant to sheath blight, brown spot, BPH, RTD, stem-borer and leaf folder, medium slender rice with high HRR (60.6%).
TRY 5 [TR 09030] (IET 26068)	Tamil Nadu	Suitable for soils with problems of salinity, yield 51.1 q/ha, maturity 105–110 days, tolerant to salinity, moderately resistant to blast, brown spot, BPH, WBPH and GLH, long slender white rice with high milling (68%) and head rice recovery (57%).
TKM 15 [TM 12077] (IET 26645)	Tamil Nadu	Suitable for *kharif* dry and semi-dry cultivation, yield 40 q/ha (dry condition) and 42.2 q/ha (semi-dry condition), maturity 118–120 days, drought tolerant, moderately resistant to stem-borer, leaf folder and gall midge, blast, sheath-rot, sheath blight, brown spot and RTD, higher proline content (2.15 mg/g), chlorophyll stability index (80.23%) and total chlorophyll content (1.51 mg/g) under water stress.
Punjab Basmati 7	Punjab	Suitable for low-land irrigated, basmati rice ecosystem, yield 48.6 q/ha, maturity 101 days after transplanting, resistant to all the pathotypes of bacterial blight prevalent in the Punjab.

Variety	Area of adoption	Salient features
Wheat (*Triticum aestivum*)		
GW 513	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur, Rajasthan and Jhansi division of Uttar Pradesh	Suitable for timely-sown irrigated, condition, yield 58.5 q/ha, maturity 119 days, contains protein (10.7%), Fe (36.3 ppm), Zn (38.7 ppm) and resistant to black rust.
Karan Aditya (DBW 332)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua district), parts of Himachal Pradesh (Una district and Paonta valley), and Uttarakhand (Tarai region)	Suitable for high fertility irrigated, early-sown condition, yield 78.3 q/ha, maturity 156 days, good grain protein (12.2%), resistant to yellow and brown rust.
Pusa Vakula (HI 1636)	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan (Kota and Udaipur division), and Western Uttar Pradesh (Jhansi division)	Suitable for timely-sown irrigated, condition, yield 56.6 q/ha, maturity 119 days, high Zn content (44.4 ppm), excellent chapati quality (8.24/10), resistant to black and brown rusts.
HUW 838	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua district), parts of Himachal Pradesh (Una district and Paonta valley), and Uttarakhand (Tarai region)	Suitable for restricted irrigation, timely-sown condition, yield 51.3 q/ha, maturity 148 days, high Zn content (41.8 ppm), superior grain quality, resistant to yellow and brown rust.
JKW-261 (Birsa Gehun-4)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua district), parts of Himachal Pradesh (Una district and Paonta valley), and Uttarakhand (Tarai region)	Suitable for late-sown irrigated, condition, yield 51.7 q/ha, maturity 120 days, heat and drought tolerant, moderately resistant to foliar diseases, brown and black rusts, and foliar diseases.
Pusa Prabhat (HI 8823)	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan (Kota and Udaipur division) and Jhansi division of Uttar Pradesh	Suitable for restricted irrigation, timely-sown condition, yield 38.5 q/ha, maturity 122 days, high Zn (40.1 ppm), protein (12.1%), good pasta acceptability (5.9), resistant to black and brown rust.
DBW 296 (Karan Aishwaraya)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua district), parts of Himachal Pradesh (Una district and Paonta valley), and Uttarakhand (Tarai region)	Suitable for restricted irrigated, timely-sown condition of NWPZ, yield 56.1 q/ha, maturity 150 days, high Fe content (40.7 ppm), tolerant to heat and drought, higher yield even under zero irrigation, resistant to yellow, brown and black rusts, and other foliar diseases.

Variety	Area of adoption	Salient features
MP (JW) 1358	Maharashtra, Karnataka and Plains of Tamil Nadu	Suitable for restricted irrigation, timely-sown condition, yield 56.1 q/ha, maturity 105 days, rich in protein (12.1%), Fe (40.6 ppm), tolerant to heat and drought and resistant to black and brown rust.
DBW 327 (Karan Shivani)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur division) and Western Uttar Pradesh (except Jhansi division), parts of Jammu and Kashmir (Jammu and Kathua district), parts of Himachal Pradesh (Una district and Paonta valley), and Uttarakhand (Tarai region)	Suitable for irrigated, early-sown situation, high fertility condition of NWPZ, yield 79.4 q/ha, maturity 155 days, tolerant to heat and drought, Zn (40.6 ppm), good chapati score (7.67/10), resistant to yellow and brown rust.
MP (JW) 1323	Madhya Pradesh	Suitable for irrigated, timely-sown condition, yield 61.5 q/ha, maturity 117 days, higher protein content (14.5%), resistant against brown and black rusts.
HUW 711 (Malviya 711)	Uttar Pradesh	Suitable for rainfed/limited irrigation condition, yield 21.85 q/ha, maturity 110–120 days, resistant to leaf and stripe rusts, and tolerant to water stress.
PBW 1 Chapati	Punjab	Suitable for irrigated, timely-sown condition, grain yield 45.1 q/ha, good chapati quality, higher protein content (12.72%), resistant to brown rust, and moderately resistant to stripe rust pathotypes.
Sunehri (PBW 766)	Punjab	Suitable for irrigated, timely-sown condition, yield 64.3 q/ha, maturity 155 days, resistant to leaf rust and moderately resistant to stripe rust.
PBW 803	South-western Punjab	Suitable for irrigated, timely-sown condition, yield 62.02 q/ha, high grain Fe concentration (41.5 ppm), resistant to brown rust and moderately resistant to stripe rust.
PBW 824	Punjab	Suitable for irrigated, timely-sown condition, yield 63.0 q/ha, maturity 156 days, moderately resistant to rusts under natural and artificial conditions over the years.
PBW 869	Punjab	Suitable for irrigated, timely-sown condition, average yield 63.1 q/ha, high level of resistance to leaf rust under natural and artificial conditions over the years.
Him Palam Gehun 3 (HPW 373)	Himachal Pradesh	Suitable for mid and low hills of HP under late-sown rainfed conditions, yield 11.2–12.8 q/acre, maturity 145–149 days, well adapted to rainfed conditions, highly resistant to yellow rust and amber semi hard bold grains with good chapati making quality.
Jammu Wheat 672	UT of Jammu and Kashmir	Suitable for early/timely-sown restricted irrigation condition up to mid hills of Jammu region, yield 44.1 q/ha, protein content 11.2%, maturity 155–170 days, restricted irrigation, resistant to yellow and black rust.
VL Gehun 2028	Uttarakhand	Suitable for timely-sown rainfed condition under organic cultivation in mid hills of Uttarakhand, yield 22.7 q/ha, protein content 10.34–12.32%, maturity 171 days, tolerant, resistant to yellow and brown rust.
VL Gehun 3010	Uttarakhand	Suitable for late-sown irrigated, condition of Uttarakhand plains, yield 58.19 q/ha, higher Fe content (44.9 ppm), maturity 126 days and resistant to yellow and brown rust.
K 1616	Uttar Pradesh	Suitable for rainfed, timely-sown condition of Uttar Pradesh, yield 23.96 q/ha, good hectoliter weight, maturity 121 days, resistance to brown rust.
Maize (*Zea mays*)		
Pusa HQPM 1 Improved	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh, Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh (Western region), Bihar, Jharkhand, Odisha, Uttar Pradesh	Suitable for irrigated, condition, yield 81.9 q/ha, maturity 110.5 days, resistant to TLB and moderately resistant to MLB and BSR.

Variety	Area of adoption	Salient features
	(Eastern region), West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat, Madhya Pradesh, Chhattisgarh, and Rajasthan	
Pusa Biofortified Maize Hybrid 1	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Meghalaya, Sikkim, Assam, Tripura, Nagaland, Manipur, Arunachal Pradesh, Bihar, Jharkhand, Odisha, Uttar Pradesh (Eastern region), and West Bengal	Suitable for irrigated, condition, average grain yield 76.3 q/ha (NHZ) and 54.4 q/ha (NEPZ), maturity: 107.4 days (NHZ) and 86.3 days (NEPZ), rich in pro-vitamin A (6.6 ppm), lysine (3.37%) and tryptophan (0.72%), orange, bold grains, resistant to TLB and moderately resistant to BSR.
Pusa HM4 Male Sterile Baby Corn (Shishu)	Punjab, Haryana, Delhi, Uttarakhand and Uttar Pradesh	Suitable for irrigated, condition, tolerant to abiotic stresses, yield 70.7 q/ha, maturity 53 days, moderately resistant to maydis leaf blight.
Malaviya Swarn Makka 1 (VEQH 1)	Punjab, Haryana, Delhi, Uttarakhand and Uttar Pradesh	Suitable for irrigated,/rainfed condition, grain yield 71.7 q/ha, maturity 93 days, protein 9.35–9.49%, tryptophan 0.69–0.97%, lysine 2.71–3.89%, moderately resistant to maydis leaf blight, charcoal rot, *Chilo partellus* and fall armyworm.
ADV 7132 (ADV 765)	Punjab, Haryana, Delhi, Uttarakhand (Plain) and Western Uttar Pradesh	Suitable for irrigated,/rainfed condition, yield 101.5 q/ha, maturity days 95–100 days, moderately resistant to maydis leaf blight, turcicum-leaf blight, charcoal rot, sorghum downy mildew, fusarium stalk rot, polysora rust and *Chilo partellus*.
L 315 (Him Palam Maize Composite 1)	Himachal Pradesh, Jammu and Kashmir, and Uttarakhand	Suitable for irrigated,/rainfed condition, yield 63.6 q/ha, maturity 101.2 days, resistant to turcicum-leaf blight, moderately resistant to BLSB, bacterial leaf and sheath disease, and resistant to TLB.
Birsa Babycorn 1 (BVM-2)	Jharkhand	Suitable for rainfed upland condition of eastern India, yield 167.0 q/ha, maturity 50–65 days (as baby corn harvesting starts at 48th day and continues till 65th day with 3 pickings), moderately resistant to TLB, MLB, moderately susceptible to BLSB, and resistant to TLB.
Sikkim Sankul Makka 1	Sikkim	Suitable for rainfed, timely-sown organic condition, yield 45.0 q/ha, maturity 130 days, moderately resistant to turcicum-leaf blight.
SKMC 2 (SKMC-03)	Sikkim	Suitable for rainfed, timely-sown organic condition, yield 58.0 q/ha, maturity 115 days, moderately resistant to turcicum-leaf blight, banded leaf and sheath blight, puccinia rust of maize, and tolerant to pest infestation of *Sesamia* and *Chilo* under natural field conditions.
Pratap Raj Hybrid Maize- 1010 (WH-1010)	Rajasthan	Suitable for *rabi* maize cultivation under irrigated, conditions in Rajasthan, average yield 97.5 q/ha, maturity 130–140 days, single cross, yellow seeded, high protein content (13.66%), thus suitable for nutritional aspects, moderately resistant to TLB, charcoal rot, PFSR and *Curvularia* leaf spot, and tolerant to stem-borer.
Pratap Raj Hybrid Maize 1095 (WH1095)	Rajasthan	Suitable for rainfed and irrigated, conditions of *kharif* season, average yield 70.4 q/ha, maturity 95–100 days, single cross, yellow seeded, high protein content (13.67%), thus suitable for nutritional aspects, resistant to MLB, TLB and RDM.
Pratap QPM Hybrid-5 (EHQ-64)	Rajasthan	Suitable for rainfed and irrigated, conditions of Rajasthan, single cross, yellow seeded quality protein maize hybrid, average grain yield 54.6 q/ha, maturity 85–90 days, 8.56% protein, 0.58% tryptophan and 2.38% lysine, responsive to higher fertility levels, resistant against PFSR and *Curvularia* leaf, maydis leaf blight, moderately resistant to maize stem-borer (*Chilo partellus*) and nematode *Heterodera zeae.*
JC 4	Punjab	Suitable for irrigated, *kharif* conditions in kandi belt, yield 32.0 q/ha, maturity 90 days, protein content 9.88%, β-carotene content 3.12 ppm, very good for chapati quality parameters, viz. taste, texture, appearance and flavour.

Variety	Area of adoption	Salient features
PMH 13	Punjab	Suitable for *kharif* season, yield 59.0 q/ha, maturity 97 days, protein 9.98% and ß-carotene 3.88 ppm.
JC 12	Punjab	Suitable for irrigated,/rainfed *kharif* conditions particularly in the traditional maize growing areas of kandi belt, grain yield 45.5 q/ha, maturity 99 days, protein content 9.72%, β-carotene content 2.94 ppm and composite variety.
RCRMH 4	Karnataka	Suitable for *kharif* rained regions of zone-3, drought tolerant, single cross hybrid, yield 50–52 q/ha, maturity 165 days, resistant to *Fusarium* wilt, moderately resistant to Sterility Mosaic Disease (SMD) and superiority over the best checks under managed drought conditions.
Pusa Biofortified Maize Hybrid 2 (APH 2)	Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh (Western and eastern region), Bihar, Jharkhand, Odisha, West Bengal, Gujarat, Madhya Pradesh, Chhattisgarh and Rajasthan	Suitable for *kharif*, irrigated, conditions, yield 75.4 q/ha, maturity 87–92 days, possesses 5.9 µg/g of pro-vitamin-A, QPM hybrid and possesses high lysine (3.47%), and tryptophan (0.92%) in endosperm protein.
Pusa Biofortified Maize Hybrid 3 (APH3)	Punjab, Haryana, Delhi, Uttarakhand (Plain), Uttar Pradesh (Western region), Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat, Madhya Pradesh, Chhattisgarh and Rajasthan	Suitable for *kharif*, irrigated, conditions, yield 82.2 q/ha, maturity 88–94 days, possesses 5.7 µg/g of pro-vitamin A, QPM hybrid and possesses high lysine (3.52%), and tryptophan (0.87%) in endosperm protein.
PMH 1-LP (EDV of PMH 1 with Low Phytate)	Punjab, Haryana, Western Uttar Pradesh, Plains of Uttarakhand and Delhi	Suitable for irrigated, high fertility, *kharif* season in NWPZ, yield 95.6 q/ha, fodder yield 80 q/ha, maturity 94 days, protein content 8.8%, low phytic acid content (1.89 mg/g), orange colour grain with yellow cap and moderately resistant to maydis leaf blight, turcicum-leaf blight, and charcoal rot.
IMH 222	Punjab, Haryana, Plain parts of Uttarakhand, New Delhi and Western Uttar Pradesh	Suitable for *rabi,* irrigated, condition, yield 101.9 q/ha, maturity medium, moderately resistant to charcoal rot in proposed NWPZ, showed resistant response to fusarium stalk rot and maydis leaf blight, moderately resistant to turcicum-leaf blight and at regional/national level, *Chilo partellus,* pink stem-borer, (*Sesamia inferens)* (under artificial epiphytotic conditions), and fall armyworm (under natural infestation).
IMH 223	Punjab, Haryana, Uttar Pradesh (Western region), Uttarakhand (Plains) and Delhi	Suitable for *rabi*, irrigated, condition, yield 104.8 q/ha, maturity medium, moderately resistant to charcoal rot in proposed NWPZ, resistant to fusarium stalk rot, turcicum-leaf blight and maydis leaf blight at regional/National level, *Chilo partellus,* pink stem-borer, (*Sesamia inferens)* (under artificial epiphytotic conditions) and fall armyworm (under natural infestation).
IMH 224	Eastern Uttar Pradesh, Bihar, Jharkhand and Odisha	Suitable for *kharif*, irrigated, condition, yield 72.3 q/ha, maturity medium, moderately resistant to maydis leaf blight in proposed NEPZ, charcoal rot and turcicum-leaf blight at regional/national level, resistant to fusarium stalk rot, *Chilo partellus,* (under artificial epiphytotic conditions) and fall armyworm (under natural infestation).
DKC 7204 (IT 7788)	Eastern Uttar Pradesh, Bihar, Jharkhand and Odisha	Suitable for *kharif*, rainfed and irrigated, condition, yield 70.0–80.0 q/ha, maturity early, moderately resistant under artificial epiphytotic conditions at hot spot locations in NWPZ, and moderately tolerant to stem-borer *Chilo partellus*.
VLQPM Hybrid 45 (FQH 165)	Jammu and Kashmir, Ladakh, Himachal Pradesh, Assam, Uttarakhand, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura	Suitable for *kharif*, rainfed condition, yield 66.7 q/ha, tryptophan and lysine (% of endosperm protein) 0.66 and 2.90 respectively, maturity medium, moderately resistant to turcicum-leaf blight, and fall army worm.
VL QPM 61	Uttarakhand	Suitable for *kharif*, rainfed condition, yield 44.4 q/ha, tryptophan and lysine (% of endosperm protein) 0.76 and 3.30 respectively, maturity early, yellow, semi-flint and medium bold grains and moderately resistant to turcicum and maydis leaf blight.

Variety	Area of adoption	Salient features
VL QPM 63	Uttarakhand	Suitable for *kharif*, rainfed condition, yield 46.8 kg/ha, tryptophan and lysine (% of endosperm protein) 0.72 and 3.20 respectively, maturity early, yellow, semi-flint and medium bold grains (avg. 1000-grain wt. 280 g), and moderately resistant to turcicum-leaf blight.
Shalimar Maize Composite 8 (KDMH-103)	UT of Jammu and Kashmir	Suitable for rainfed conditions, yield 60–65 q/ha, maturity 125–130 days, drought-tolerant composite, and resistant to CLS, TLB, and stem-borer.
Shalimar Maize Hybrid 4 (H 64)	UT of Jammu and Kashmir	Suitable for high altitudes of Kashmir between 1800–2250 m, yield 57.0 q/ha, maturity 140–145 days, cold-tolerant hybrid, resistant to TLB and common rust.
RC Manichujak 2	Manipur	Suitable for *kharif* season of the valley, foot hills and hill region of the Manipur state, yield 33.2 q/ha, maturity 105 days, good performance in heat and drought condition, resistant to lodging, shattering, and fertilizer response is very good, moderately tolerant to fall armyworm, turcicum-leaf blight, bacterial leaf blight, and bacterial sheath blight.
CP 333	Assam	Suitable for rainfed conditions and for zone V, yield 94.7 q/ha, maturity late 120–130 days, tolerant to TLB and charcoal rot, resistant to *S. inferens*, high yield and disease resistance, long conical cob and attractive orange colour grains.
Barley (*Hordeum vulgare*)		
KB 1425 (Azad Barley 33)	Uttar Pradesh	Suitable for saline/alkaline soils under irrigated, condition, average grain yield 33.07 q/ha, maturity 120 days, resistant to yellow, brown rust and leaf blight.
Him Palam Jau 2 (HBL-804)	Himachal Pradesh	Suitable for dual-purpose, recommended for timely-sown rainfed and irrigated, conditions in low and mid hills of Himachal Pradesh, yield 25–30 q/ha, maturity 175–185 days, CP 9.9%, high degree of resistance to stripe, and brown rusts.
Sorghum (*Sorghum bicolor*)		
Parbhani Supermoti (SPV 2407)	Maharashtra (Marathwada Region)	Suitable for timely-sown, rainfed areas of Marathwada region, yield 31.9 q/ha, maturity 118–120 days, resistant to insect-pest, moderately tolerant to shootfly, stem-borer, and charcoal rot
Palem Jonna 1 (PSV 512)	Telangana	Suitable for rainfed condition, yield 35.0 q/ha, maturity 100–105 days, moderately to grain mold disease, shootfly and stem-borer.
Tandur Jonna 1 (SVT 68)	Telangana	Suitable for irrigated,/rainfed *rabi* ecology, yield 28–30 q/ha, protein 10.37%, Fe 41.86 mg/kg, Zn 26.67 mg/kg, Ca 177.60 mg/kg, maturity 115–120 days, moderately resistant to charcoal rot, tolerant to shootfly, stem-borer, aphids, and terminal moisture stress.
Gujarat Jowar 44 (Madhu)	Gujarat	Suitable for rainfed condition during *kharif* season, yield 27.6 q/ha, maturity 110 days, moderately resistant to the grain mold, ergot, anthracnose and leaf blight, good chapati quality with higher in grain chemical quality parameters, viz. sugar, starch, carbohydrate, protein and zinc content.
Jaicar Raseela- CSV 49SS (SPV 2600)	Maharashtra, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu, Gujarat, Madhya Pradesh, Uttar Pradesh and Punjab	Suitable for rainfed/irrigated, conditions and timely-sown conditions, yield 45.4 q/ha, maturity 123 days, resistant to downy mildew, rust, leaf blight and rough leaf spot diseases, tolerant to shootfly, and stem-borer.
Jaicar Urja- CSV 48 (SPV 2402)	Maharashtra, Telangana, Gujarat, Madhya Pradesh, Punjab and Uttarakhand	Suitable for rainfed/irrigated, timely-sown conditions, high biomass sorghum variety foe 2nd generation bio-fuel, fresh biomass yield 560 q/ha, dry biomass yield 210 q/ha, ethanol yield (2G) - 374 l/tonnes of biomass, maturity 140 days, resistant to leaf blight, superior to the checks for lower shootfly and stem-borer dead heart formation.
Jaicar Varsha CSH 45 (SPH 1888)	Karnataka, Maharashtra, Rajasthan and Telangana	Suitable for rainfed ecology during *kharif* season, yield 44.6 q/ha, maturity 105 days, moderately resistant to grain molds, tolerant to shootfly and stem-borer.
CSH 47 (SPH 1798)	Maharashtra, Gujarat, Madhya Pradesh, Haryana, Punjab, Uttarakhand and Telangana	Suitable for early to normal sown condition, fresh biomass yield 665 q/ha, dry biomass yield 243 q/ha, grain yield 7.73 q/ha, high total ethanol yield (380 l/tonnes), maturity 127–144 days, moderately tolerant to shootfly and stem-borer, resistant to lodging, and responsive to fertilizer.

Variety	Area of adoption	Salient features
CSV 45 (SPV 2504)	Maharashtra, Madhya Pradesh and Tamil Nadu	Suitable for rainfed, timely-sown, grain yield 33.4 q/ha, fodder yield 85.0 q/ha, maturity 110 days, high water absorption capacity (80.0 ml/100 g), crude protein 8.72%, high soluble protein (0.87), resistant to insect-pests, promising performance against shootfly (dead hearts) % at 28 days, stem-borer leaf injury rating at 35 days, stem-borer dead hearts % at 45 days, aphid damage rating.
Gujarat Jowar 101 (GJ 101: *Madhu Moti*)	Gujarat	Suitable for Gujarat for *rabi* adaptation, yield 25.0 q/ha, good grain quality, high protein, Fe and Zn content in chapati, maturity 118 days, moderately resistant to grain mold, sugary disease, anthracnose and leaf blight, good in fodder quality with high crude protein, NDF, and calcium.
Gujarat Dantiwada Jowar 1 [GDJ 01: Banas Surya]	Gujarat	Suitable for *kharif* sorghum growing areas of Gujarat, yield 25.0 q/ha, 10.10% /g crude protein, 0.165% /g tryptophan and low tannin (0.215% mg/g), dry-fodder contains 9.20% crude protein and 24.24% crude fiber, grain yellow white in color, maturity 102 days, moderately resistant to anthrocnose, leaf blight, grain mold and ergot disease, moderately tolerant to shoot-fly, and stem-borer.
Parbhani Shakti (PVK 1009)	Maharashtra	Suitable for *kharif* rainfed area of Maharashtra, yield 36.0 q/ha, maturity 108 days, Fe and Zn rich *kharif* sorghum variety resistant to pest and diseases.
Phule Revati (RSV 1006)	Gujarat	Suitable for irrigated, timely-sown recommended area of Maharashtra, grain yield 45.9 q/ha, crude protein 9.83%, crude fibre 1.35% and total sugar 1.77%, maturity 119 days, moderately tolerant to shootfly, stem-borer, and moderately resistant to charcoal rot.
Pearl millet (*Pennisetum glaucum*)		
PA 9385 (MSH 353 (PB 1877)	Gujarat, Rajasthan, Uttar Pradesh, Punjab, Maharashtra and Tamil Nadu	Suitable for irrigated, early to late-sown as well as timely-sown condition, grain yield 48.7–52.4 q/ha, Fe 53 ppm, Zn 36 ppm, maturity 88 days, resistant to downy mildew, tolerant to high temperature and lodging.
HHB 67 Improved 2	Rajasthan, Haryana and Gujarat	Suitable for early, timely as well as late planting, average grain yield 20.0 q/ha, maturity 76 days, resistant to downy mildew, blast, smut, rust and ergot, tolerant to drought.
NBH 5929 (MH 2423)	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Punjab and Delhi	Suitable for rainfed (onset of monsoon), yield 39 q/ha, maturity 85–87 days and highly resistant to DM, and blast disease.
RHB 228 (MH 2098)	Rajasthan	Suitable for rainfed, *kharif*, both high and low fertility, yield 28.0 q/ha, protein 9.4%, maturity 75 days, resistant to downy mildew, blast and smut.
GHB 1231 (Sawaj Shakti)	Gujarat	Suitable for rainfed condition during *kharif*, average grain yield 27.6 q/ha, quality traits biofortified hybrid having high Fe (81 ppm) and Zn (41 ppm) in its grain, maturity 82 days, resistant to high level and downy mildew blast, rust, ergot and smut, stem-borer, shootfly, and tolerant to lodging.
PCB 165 (GBL 2)	Punjab	Suitable for dual-purpose, all bajra growing areas of the state, fodder yield 585.2 q/ha, grain yield 32.1 q/ha, maturity (seed to seed) 105–115 days, tolerant to major diseases, viz. downy mildew, ergot, smut, blast, and insect-pests, viz. grass-hopper and pyrilla.
VPMV 9	Adoption endorsement in state for Karnataka	Suitable for dual purpose, grain yield 26–28 q/ha, fodder yield 71.91 q/ha, maturity 80–85 days, compact panicle, high tillering and grains are rich in Fe (66 ppm), and Zn (39 ppm) content.
86M80 (MH 2439)	Gujarat, Rajasthan, Haryana, Uttar Pradesh, Madhya Pradesh, Punjab and Delhi	Suitable for *kharif* rainfed cultivation, yield 39.4 q/ha, yield 123 q/ha, maturity 88 days, resistant to high temperature, lodging, and DM, tolerant to rust, and insect-pests.
SVPMH 101 (MSH 361)	Gujarat, Rajasthan, Maharashtra, Uttar Pradesh, Punjab, Telangana and Tamil Nadu	Suitable for summer irrigated, cultivation, yield 47.30 q/ha, maturity 88 days, resistant to downy mildew and lodging.

Variety	Area of adoption	Salient features
MPMH 35 (MH 2474) Maru Sampada	Rajasthan, Gujarat and Haryana	Suitable for *kharif* rainfed cultivation in dry regions, yield 22 q/ha, maturity 75 days, highly resistant to downy mildew, blast, insect-pests and resistant to smut.
MH 2480 (86M94)	Rajasthan, Gujarat, Haryana, Madhya Pradesh, Uttar Pradesh, Punjab and Delhi	Suitable for *kharif* rainfed cultivation, yield 36.3 q/ha, maturity 82 days, resistant to high temperature and lodging and DM, tolerant to rust, and insect-pests.
BLPMH 109 (MSH 363)	Gujarat, Rajasthan, Uttar Pradesh, Punjab, Maharashtra, Tamil Nadu and Telangana	Suitable for summer irrigated, cultivation, yield 47.3 q/ha, maturity 89 days, resistant to downy mildew and lodging.
Little millet (*Panicum sumatrense*)		
Chhattisgarh Sonkutki (BL 41-3)	Chhattisgarh	Suitable for rainfed, water stress conditions, non-lodging and non-shattering, responsive to fertilizers, yield 15.8 q/ha, maturity 95–100 days, moderately resistant to shootfly, tolerant to moisture stress, and moderate drought spells.
Kalinga Saun 217 (OLM 217)	Odisha	Suitable for early sowing *kharif* season, yield 15.4 q/ha, late maturity 117 days, resistant to brown spot, moderately resistant to banded blight and *Cercospora* leaf spot, shootfly, non-lodging, and non-shattering.
Finger millet (*Eleusine coracana*)		
CFMV 3 (Ekvijay)	Andhra Pradesh, Tamil Nadu, Telangana, Maharashtra and Gujarat	Suitable for profuse tillering, highly suitable for rainfed cultivation, yield 32.17 q/ha, maturity 120–125 days, moderately resistant to leaf blast, finger blast, neck blast, foot-rot and banded blight (PDI), higher protein (6.98%), total mineral matters (4.33%), Fe (3.80 mg/100 g), Zn (2.46 mg/100 g) and Ca (470 mg/100 g).
Chhattisgarh Ragi 3 (FMV 1102) (BR 14-3)	Assam, Bihar, Chhattisgarh, Jharkhand, Uttarakhand and Madhya Pradesh	Suitable for rainfed, water stress conditions, non-lodging and non-shattering, responsive to fertilizers, yield 32.0 q/ha, maturity 110–115 days, tolerant to finger, neck and leaf blast disease, moisture stress and moderate drought spells, moderately resistant to grass-hopper, and shoot aphid.
ATL 1 (TNEc 1285)	Tamil Nadu	Suitable for rainfed/irrigated, condition, average grain yield 30.1 q/ha, maturity 105–110 days, resistant to leaf, neck and finger blast, and tolerant to drought.
Dapoli 3 (DPLN 2)	Maharashtra	Suitable for traditional finger millet growing areas during *kharif* season and 3–5% sloppy upland rainfed ecosystem of Konkan region, grain yield 20–22 q/ha, maturity 120–122 days, moderately resistant to leaf blast at field level, resistant to aphids, contains protein 7.52%, Ca 264 ppm, and Fe 121 ppm.
Birsa Marua 3	Jharkhand	Suitable for rainfed upland ecology/timely-sowing, yield 26.9 q/ha, maturity 110–112 days, moderately resistant to neck, finger blast, resistant to brown spot, banded sheath blight, foot-rot and major insect/pests, viz. *Myllocerus* weevil, ear head caterpillars, stem-borers, grasshoppers, and tolerant to moisture stress during dry spell.
Gossaigaon Marua Dhan (AAU-GSG-Marua Dhan 1) (FMV 1156)	Assam	Suitable for rainfed, low fertile, *kharif* season, yield 23–25 q/ha, maturity 125–130 days, lodging and shattering, moderately resistant to leaf blast and neck blast, high in crude protein (10.67%), crude fibre (11.75%), Ca (300 mg/100 g), and Fe (8.91 mg/100 g).
Phule Kasari (KOPN 942)	Maharashtra	Suitable for timely-sown and transplanting condition, yield 18–20 q/ha, maturity 100–110 days, resistant to neck and finger blast disease.
Kodo millet (*Paspalum scrobiculatum*)		
CKMV 1 (ATL 2)	Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Tamil Nadu and Telangana	Suitable for early and late sowing in *kharif* as sole as well as intercropping systems, yield 28.1 q/ha, maturity 106–110 days, tolerant to brown spot, leaf blight and head smut.
Dahod Kodo (CKMV 2)	Andhra Pradesh, Chhattisgarh, Gujarat, Madhya Pradesh and Tamil Nadu	Suitable for rainfed situation, grain yield 28.92 q/ha, maturity 105–110 days, moderately resistant to head smut, banded blight, leaf blight, brown spot and shootfly damage (16.6%), good amount of protein (6.2%), Zn (2.6 mg/100 g) and Fe.

Variety	Area of adoption	Salient features
Chhattisgarh Kodo 03 (BK 36)	Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh and Tamil Nadu	Suitable for well drained, rainfed, upland, early-sown under both high and low soil fertility conditions, yield 26.4 q/ha, maturity 105–110 days, moderately resistant to shootfly, tolerant to banded blight, smut disease and moisture stress, and moderate drought spells.
Gujarat Kodo millet 4 (Dahod Kodra)	Gujarat	Suitable for rainfed/hilly condition, yield 27.4 q/ha, medium maturity, high protein (8.7%), fibre (8.4%), ash (0.25%), Fe (38.95 mg/kg), Zn (21.94 mg/kg), Cu (6.86 mg/kg) with higher milling recovery (55.5%), long panicle and raceme length, non-shattering in habit, and moderately resistant to head smut disease.
ATL 1 (TNPsc 176)	Tamil Nadu	Suitable for rainfed condition during Aadi (June-August) and Purattasi (September–October) pattam, grain yield 25.1 q/ha, maturity 105–110 days, resistant to grain smut, sheath blight and tolerant to drought, grains are rich in protein, mineral, dietary fibre contents, palatable, and nutritious fodder value.
Barnyard millet (*Echinochloa frumentacea*)		
Phule Barti 1 (KOPBM 46)	Maharashtra	Suitable for timely-sown condition, yield 15–20 q/ha, maturity 95–105 days and any major pests and diseases have not been observed.

Oilseeds: Fifty seven high yielding oilseed varieties comprising 7 each of soybean and safflower, 4 each of linseed, niger and gobhi sarson, 5 of sunflower, 9 of Indian Mustard, 6 of groundnut, 1 each of castor, taramira and toria and 8 were released for different agro-ecological regions.

List of improved released varieties/hybrids of oilseeds

Variety	Area of adoption	Characters
Indian Mustard (*Brassica juncea*)		
Pusa Double Zero Mustard 33	Jammu, Punjab, Haryana, Delhi and Northern Rajasthan	Suitable for timely-sown, irrigated, condition, grain yield 26.4 q/ha, oil content 38%, maturity 141 days, low erucic acid (1.13%) in its oil and low glucosinolates in the seed meal (15.17 ppm), resistant to white rust disease, tolerant to water stress, and yellow seeded.
RCH 1	Jammu, Punjab, Haryana, Delhi and northern Rajasthan	Suitable for timely-sown, irrigated, condition, grain yield 26.7 q/ha, oil content 39.5%, maturity 149–155 days, resistant to white rust, tolerant to *Alternaria* blight, *Sclerotinia* stem-rot, powdery and downy mildew, aphid attack, and moderately tolerant to moisture stress.
TAM 108-1	Maharashtra	Suitable for timely-sown condition in *rabi* season under restricted irrigation, yield 32.4 q/ha, oil content 40.09%, and resistant to aphids.
PHR 126	Punjab	Suitable for timely-sown, irrigated, ecologies, grain yield 22.7 q/ha, oil content 40.2%, maturity 145 days and tolerant to *Alternaria* blight, white rust, and aphid attack.
Birsa Bhabha Mustard 1(BBM 1)	Jharkhand	Suitable for timely-sown, rainfed medium land ecology, grain yield 15.6 q/ha, oil content 40.03%, maturity 114–121 days, moderately resistant to *Alternaria* blight, white rust and powdery mildew, moderately tolerant to mustard aphids, and tolerant to moisture stress/drought.
Trombay Him Palam Mustard 1 (THPM 1)	Himachal Pradesh	Suitable for timely-sown, irrigated, condition in low and mid-hill zone of Himachal Pradesh, grain yield 10.8 q/ha, oil content 39.9%, maturity 153 days, moderately susceptible against *Alternaria* blight at leaf stage and moderately susceptible to susceptible against white rust.
KMR 16-2 (Surekha)	Uttar Pradesh	Suitable for irrigated, timely-sown condition, yield 16.7 q/ha, oil content 42.6%, maturity 125–130 days, tolerant to heat, resistant to *Alternaria* blight and white rust.
Trombay Bidhan Mustard 143 (TBM 143)	West Bengal	Suitable for irrigated, condition, yield 14.1 q/ha, oil content 41.3%, maturity 104 days and moderately resistant to *Alternaria* leaf spot.
Jammu Mustard 135 (JM 13-5)	UT of Jammu and Kashmir	Suitable for irrigated, condition, yield 17.0 q/ha, oil content 38–39.6%, maturity 135–145 days, resistant to lodging and moderately resistant to white rust, and *Alternaria* blight.

Variety	Area of adoption	Characters
PGSH 1699	Himachal Pradesh, Jammu and Kashmir, and Punjab	Suitable for timely-sown, irrigated, condition, seed yield 15.8 q/ha, oil content 41.92%, maturity 168 days, low erucic acid (1.7%) and low glucosinolate (16.87 µmoles/g), canola '00' variety, low disease severity for white rust and *Alternaria* blight at both at leaf and pod stages and resistant to downy mildew, powdery mildew, and *Sclerotinia* stem-rot.
Him Palam Gobhi Sarson 1 (AKMS 8141)	Himachal Pradesh, Punjab, Jammu and Kashmir.	Suitable for irrigated, timely-sown condition, yield 19.1 q/ha, oil content 37.5–42.8%, maturity 166 days, free from white rust and at par with other prevalent diseases and insect-pest with gobhi sarson check.
PGSH 1707	Punjab	Suitable for timely-sown and irrigated, condition, seed yield 21.9 q/ha, oil content 41%, maturity 162 days, first CMS based canola quality ('00') hybrid of gobhi sarson in India, low erucic acid and low glucosinolate, resistant to white rust, and at par with checks for its reaction to *Alternaria* blight and mustard aphid.
Jammu Gobhi Sarson 123 (JGS 12-3)	UT of Jammu and Kashmir	Suitable for irrigated, condition of Jammu and Kashmir, yield 18.4 q/ha, oil content 38–41.2%, maturity 150–160 days, moderately resistant to white rust and *Alternaria* blight.
Toria (*Brassica rapa*)		
AAU TS 38	Assam, Arunachal Pradesh, Manipur, Nagaland, Mizoram, West Bengal, Odisha and Jharkhand	Suitable for timely-sown, rainfed *rabi* condition in alluvial sandy loam and other light soils, also suitable for both early and late-sown condition, seed yield 12 q/ha, oil content 41.4%, oil yield 781.3 kg/ha, maturity 85–95 days, moderately susceptible to *Alternaria* blight, moderately resistant to *Sclerotinia* rot, white rust, downy mildew and moderately susceptible to mustard aphid and mustard sawfly.
Taramira (*Eruca vesicaria)*		
Krishna Tara (RTM 1624)	Rajasthan	Suitable for rainfed, *rabi*, arid and semi-arid region with optimum fertility level, yield 12.0 q/ha, oil content 39–39.8%, maturity 139 days, fairly tolerant to moisture stress, resistant to white rust and stage head, moderately resistant to downy mildew, powdery mildew, and less infestation of mustard aphid.
Groundnut (*Arachis hypogaea*)		
Gujarat Groundnut 35 (Sorath Gold)	Gujarat	Suitable for *kharif* season, pod yield 31.8 q/ha, oil content 49.84%, oil yield 1130 kg/ha, maturity 105 days, variety is comparable to the checks against tikka, rust, stem-rot and collar rot, lower infestation due to leaf defoliators.
Gujarat Groundnut 23 (Sorath Kiran)	Gujarat	Suitable for *kharif* season, pod yield 27.2 q/ha, oil content 49.72%, oil yield 966 kg/ha, maturity 121 days and reactions against stem-rot, collar rot, and rust is comparable to checks.
CG Mungfali 1 (CGM 1)	Chhattisgarh	Suitable for *kharif* (both rainfed and irrigated, condition), yield 42.2 q/ha, oil content 52%, maturity 121 days, moderately resistant to early leaf spot and late leaf spot, and rust.
Kalinga Groundnut 101 (ICGV 02266)	Odisha	Suitable for *rabi*-summer rainfed/restricted irrigated, conditions, grain yield 22.3 q/ha, kernel yield 16.2 q/ha, oil content 50%, maturity 125–131 days, moderately resistant to ELS/LLS, rust, *Alternaria* blight, stem-rot/collar rot, thrips, jassids, *Spodoptera*, leaf-miner, and tolerant to drought.
TAG 73 (TAG 14-73)	Vidarbha region of Maharashtra	Suitable for summer with irrigated, condition, pod yield 25–28 q/ha, oil content 48–49%, maturity 110–115 days, moderately resistant to major diseases (tikka, collar-rot and stem-rot) and pests (jassids, thrips and aphids).
VRI 9 (VG 13163)	Tamil Nadu	Suitable for rainfed and irrigated, conditions, pod yield 25.3 q/ha (*kharif*), 29.21 q/ha (*rabi*), oil content 49–50%, maturity 110–115 days, moderately resistant to late leaf spot (LLS), rust, sucking pests, and defoliators.
Soybean (*Glycine max*)		
Phule Durva (KDS 992)	Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	Suitable for rainfed, *kharif* season, yield 26.6 q/ha, oil content 19.3%, maturity 101 days, highly resistant to purple seed stain and moderately resistant to rust, and defoliators.

Variety	Area of adoption	Characters
AISb 50 (Adilabad Indore Soya Chikkudu-1)	Telangana	Suitable for rainfed and irrigated, conditions, grain yield 21–30 q/ha, maturity 99–104 days, resistant to pod blight, frog-eye leaf spot, *Alternaria* leaf spot and moderately resistant to charcoal rot, defoliators, and stem girdler, tolerant to shattering even on delayed harvesting up to 8–10 days.
Birsa Soybean-3 (BAUS-40)	Jharkhand	Suitable for rainfed condition, yield 25–30 q/ha, maturity 115–120 days, tolerant to pod blight, bacterial blight, target leaf spot, aerial web blight, FLS and CLS, moderately resistant to defoliators, pod-borers, stem-fly across the zone and resistant to Bihar hairy caterpillar, and leaf roller in Jharkhand.
Him Palam Hara Soya 1	Himachal Pradesh	Recommended for sowing during *kharif* season under rainfed conditions in mid hill zone of HP, yield 23.5 q/ha, maturity medium to late, green and bold seeded (sweeter in taste), used for vegetable purpose as green peas and dry seeds like pulses variety, resistant against FLS, PB and BP.
RSC 10-71	West Bengal, Bihar, Jharkhand, Chhattisgarh, and Odisha	Suitable for high rainfall and medium to heavy soil condition, yield 19.0 q/ha, maturity 107 days, tolerant to drought condition, resistant to charcoal rot, bud blight, bacterial pustules, leaf spot, stem- fly, stem-borer and defoliators.
Birsa Soybean-4 (BAU Ranchi)	Jharkhand	Suitable for rainfed, *kharif* condition, yield 26.7 q/ha, maturity 105–110 days, tolerant to powdery mildew, *Rhizoctonia* aerial blight, target leaf spot, bacterial pustules, *Myrothecium* leaf spot and pod blight.
Chhattisgarh Soya 11-15	Chhattisgarh	Suitable for medium to high rainfall conditions and medium to heavy soils of Chhattisgarh state, yield 25.1 q/ha, maturity 98–103 days, tolerant to drought condition, multiple resistant against biotic stresses like charcoal rot, bud blights, bacterial pustules and leaf spots.
Linseed (*Linum usitatissimum*)		
SHUATS - ALSI 2 (SHA-2)	Uttar Pradesh	Suitable for irrigated, conditions in high/low fertility soils during *rabi* season, seed yield 11.1 q, oil content 37.40%, maturity 123–125 days, resistant to powdery mildew, rust and moderately resistant to wilt and *Alternaria* blight
Sabour Tisi 3 (BRLS 107-1)	Uttar Pradesh (excluding Bundelkhand), Bihar, Jharkhand, West Bengal, Assam, Nagaland, Bundelkhand of Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Chhattisgarh, Odisha and Karnataka	Suitable for *Utera* cultivation for high/low fertility regions during *rabi* season, seed yield 5.5 q/ha, oil content 38.2%, maturity 118 days, resistant to wilt and powdery mildew, moderately resistant to rust, and moderately susceptible to *Alternaria* blight.
Sabour Tisi 2 (Sabour 101)	Bihar	Suitable for irrigated, high/low fertility during *rabi*, seed yield 18.8 q/ha, oil yield 7.12 q/ha, oil content 37.81%, medium maturity (122 days), resistant against rust, *Alternaria* blight, wilt and powdery mildew in field condition, rust and moderately resistant to *Alternaria* blight in artificial condition.
Birsa Tisi-1 (BAU15 03)	Jharkhand	Suitable for irrigated, situations in high/low fertility soils during *rabi* season, seed yield 15.2 q, oil content 37.8%, maturity 122 days, resistant to wilt, rust, powdery mildew, and moderately resistant to *Alternaria* blight.
Safflower (*Carthamus tinctorius*)		
Phule Gold (SSF 15-65)	Maharashtra, Karnataka, Telangana and Andhra Pradesh	Suitable for both for rainfed and irrigated, condition, seed yield 16.7 q/ha, oil yield 575 kg/ha, oil content 34.6%, maturity 125 days, moderately resistant to *Fusarium* wilt, moderately tolerant to aphid and *Alternaria* leaf spot (the incidence of *Alternaria* was less than 10% under natural conditions).
Phule Kiran (SSF 16-02)	Maharashtra, Karnataka, Telangana, Andhra Pradesh, Madhya Pradesh and Chhattisgarh	Suitable for both for rainfed and irrigated, condition of safflower growing areas of the country, seed yield 20.6 q/ha, oil yield 632 kg/ha, oil content 30.55%, maturity 125–130 days, moderately tolerant to aphid and *Alternaria* leaf spot (incidence of *Alternaria* and *Fusarium* wilt was less than 10% under natural conditions).
DSAF-1 (ANG-18-02)	Karnataka, Maharashtra, Telangana and Andhra Pradesh	Suitable for both irrigated, and rainfed condition, seed yield 18.0 q/ha, fodder yield 18 q/ha, oil content 28.18%, maturity 125–127 days and resistant to *Fusarium* wilt.

Variety	Area of adoption	Characters
Annigeri 2020 (ANG 17-102)	Maharashtra, Karnataka, Telangana and Andhra Pradesh	Suitable for both irrigated, and rainfed condition, seed yield 18.0 q/ha, fodder yield 16–17 q/ha, oil content 28.6%, maturity 123–130 days and moderately resistant to any diseases, and insect pests.
RVSAF 14-1(Raj Vijay Safflower 14-1)	Madhya Pradesh	Suitable for irrigated, and rainfed condition, seed yield 17.5 q/ha, oil content 30%, maturity 127–135 days, spiny bold seeded, and tolerant to aphids.
RVSAF 18-1(Raj Vijay Safflower 18-1)	Madhya Pradesh	Suitable for irrigated, and rainfed condition, seed yield 17.6 q/ha, oil content 38.99%, maturity 127–131 days, moderately resistant to *Alternaria* leaf spot, and resistant for *Fusarium* wilt.
PBNS 184	Maharashtra, Karnataka, Andhra Pradesh and Telangana	Suitable for rainfed and irrigated, condition, yield 15.3 q/ha, oil content 31.3%, maturity 120–123 days, moderately resistant to *Fusarium* wilt, tolerant to *Alternaria* leaf spot, and moderately tolerant to aphid pest.
Castor (*Ricinus communis*)		
YTP 1 (YRCS 1205)	Tamil Nadu	Suitable for irrigated, and rainfed tracts, average yield 31.1 q/ha, oil content 49%, maturity 115–120 days, resistant to wilt, semilooper, *Spodoptera*, thrips and capsule borer.
Sesame (*Sesamum indicum*)		
Gujarat Til 11 (AT 324)	Telangana, Maharashtra, Karnataka, West Bengal, Madhya Pradesh, Bihar, Andhra Pradesh and Tamil Nadu	Suitable for irrigated,/timely-sown summer season, grain yield 8.4–8.5 q/ha, oil content 47–48%, maturity 85–90 days, black seeded, moderately resistant to *Macrophomina* stem, stem/root and resistant to *Alternaria* leaf spot, *Cercospora* leaf spot, and phyllody.
Jagtiala Til 2 (JCS 2454)	Telangana	Suitable for cultivation during summer, seed yield 9.5–10.0 kg/ha, oil content 46–49%, maturity 90–95 days, Fe 130.07 mg/kg, Zn 69.8 mg/kg, Ca 12630 mg/kg, Ecosenoic acid 0.21% and high in unsaturated fatty acids, viz. 40.86% oleic acid and 41.95% linoleic acid, white seeded, moderately tolerant to drought and moderately resistant to powdery mildew, and *Alternaria* leaf spot.
MT-2013-3 (BUAT Til-1)	Uttar Pradesh	Suitable for rainfed condition, grain yield 4.66 q/ha, oil content 47.5%, maturity 82 days, moderately resistant to *Alternaria* leaf spot, and resistant to *Macrophomina* stem/root-rot, *Cercospora* leaf spot and bacterial leaf spot, resistant to capsule borer and moderately resistant to bud fly/gall fly.
Kalinga Sesame 3-1 (OSC 79)	Odisha	Suitable for *kharif* season, seed yield 5.7 q/ha, oil content 40–51%, maturity 80–85 days, resistant to *Alternaria* leaf spot, moderately resistant to *Macrophomina* stem and root-rot, *Phytopthora* blight, powdery mildew, *Cercospora* leaf spot, and bacterial leaf spot.
JCS 3202 (Telangana Til-1)	Maharashtra, Karnataka and Telangana	Suitable for summer cultivation, yield 8.5 q/ha, oil content 44.2%, maturity 91–95 days, moderately resistant to *Macrophomina* stem and root-rot, *Alternaria* leaf spot, *Cercospora* leaf spot, and phyllody.
VRI-4	Maharashtra, Telangana, Karnataka, Bihar, Madhya Pradesh, Odisha, Andhra Pradesh, West Bengal and Tamil Nadu	Suitable for *rabi*/summer season cultivation, yield 9.6 q/ha, oil yield 3.80 q/ha, maturity 85–90 days, resistant to phyllody and *Cercospora* leaf spot diseases, and moderately resistant to powdery mildew, *Alternaria* leaf spot and dry root-rot diseases.
AAU SHL TIL1	Assam	Suitable for summer season in Assam under rainfed condition, yield 9.0 q/ha, oil content 46–49%, maturity 80–85 days, resistant to *Phytophthora* blight and phyllody, resistant to leaf webber, and moderately resistant to capsule borer.
PCUS 18-1(Unnat Rama)	Madhya Pradesh, Bihar, Andhra Pradesh, West Bengal, Odisha and Tamil Nadu	Suitable for *rabi* summer cultivation under irrigated, in both high and low fertility conditions, yield 9.51 q/ha, oil content 46.35%, maturity 86–90, moderately resistant to *Macrophomina* stem, root-rot, *Alternatia* leaf spot, *Cercospora* leaf spot and moderately resistant to leaf webber, capsule borer, leaf-hopper, and mirid bug.
JNS 2016-1115	All India	Suitable for rainfed and irrigated, condition, yield 6.50–7.00 q/ha, oil content 39–40%, maturity 96–102 days, tolerant to *Cercospora* leaf spots, *Alternaria* leaf spots, powdery mildew and moderately tolerant to aphids, semilooper, and caterpillar.

Variety	Area of adoption	Characters
JNS 2015-9	Madhya Pradesh	Suitable for rainfed as well as irrigated, hills and plain condition, yield 5.50–6.00 q/ha, oil content 37–38%, maturity 99–103 days, moderately tolerant to aphids, semilooper and caterpillar, tolerant to *Cercospora* and *Alternaria* leaf spots, and powdery mildew.
JNS 521	Madhya Pradesh	Suitable for rainfed as well as irrigated, hills and plain condition, yield 5.50–6.00 q/ha, oil content 37–38%, maturity 99–109 days, shining black seed, tolerant to *Alternaria* leaf spot and powdery mildew, tolerant to aphids, semilooper, and caterpillar.
JNS 2016-1413	Chhattisgarh and Jharkhand	Suitable for *kharif* season, yield 6.30 q/ha, oil content 39.5%, maturity 95 days, escape of problem of moisture scarcity, tolerant to *Cercospora, Alternaria* leaf spot, powdery mildew, Niger caterpiller, white-fly, and leaf-hopper.
Tilhan Tech SUNH-1 ((IIOSH-15-20)	Uttarakhand, Jammu and Kashmir, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, and Telangana	Suitable for both *kharif* and *rabi* seasons under rainfed and irrigated, condition, seed yield 20.0 q/ha, oil yield 7.46 q/ha, oil content 37.5%, maturity 90–100 days, resistant to downy mildew and moderately resistant to *Alternariaster* leaf blight, and powdery mildew.
PSH 2080	Punjab	Suitable for cultivation during irrigated, spring medium to high fertility condition, seed yield 24.2 q/ha, oil yield 10.8 q/ha, maturity 97 days, oil content 43.7% and moderately resistant to head rot, charcoal rot, and major insect-pests.
KBSH-85	Gujarat, Maharashtra and Northern Karnataka, Andhra Pradesh, Southern Karnataka, Tamil Nadu and Telangana	Suitable for *kharif* under both rainfed and irrigated, timely-sown conditions, yield 18.3 q/ha, oil yield 6.62 q/ha, oil content 36%, maturity 90–100 days, and highly resistant to downy mildew.
BLSFH-15004	Bihar, Haryana, Punjab, Odisha, Chhattisgarh, Maharashtra, Karnataka and Telangana	Suitable for both *kharif* and *rabi* seasons under irrigated, conditions, yield 19.6 q/ha, oil yield 7.38 q/ha, oil content 37.8%, maturity 95–100 days, highly resistant to downy mildew, moderately resistant to *Alternaria*, and powdery mildew.
Arko Provo (WBSH-2021)	West Bengal	Suitable for irrigated, condition during *rabi*/summer season and also suitable for irrigated, ecosystem of zone III, yield 32.5 q/ha, maturity 105–110 days, oil content 38.5%, resistant to leaf curl, collar rot and moderately resistant to *Alternaria* leaf spot, powdery mildew, and downy mildew.

Pulses: Sixty five high-yielding varieties of pulses comprising 18 of chickpea, 10 each of pigeonpea and black-gram, 8 of greengram, 6 of cowpea, 3 of each lentil and horse gram, 2 of rajmash and one each of fieldpea, fababean, clusterbean, broad bean and winged bean were released for different agro-ecological regions.

List of improved released varieties/hybrids of pulses

Variety	Area of adoption	Salient features
Chickpea (*Cicer arietinum*)		
IPCK 13-163 (Madhav) Kabuli	Punjab, Haryana, Uttar Pradesh and Plains of Uttarakhand	Suitable for irrigated, timely-sown condition, yield 19.7 q/ha, maturity 130–158 days (147 day), 100-seed weight 28.7 g, protein content 20.96% and resistant to wilt.
IPCL 4-14 (IPCMAS 1)	Punjab, Haryana, Western Uttar Pradesh and Plains of Uttarakhand	Suitable for timely-sown, rainfed condition, yield 16.6 q/ha, protein content 18.1%, maturity 128–133 days and MABC derived improved drought tolerant introgression line in genetic background of DCP 92-3 possessing "QTL hot spot" region for drought-tolerance gene on linkage group 4 (LG 4).
Pant Gram 8 (PG 170)	Uttar Pradesh and Uttarakhand	Suitable for rainfed/irrigated, condition, yield of 16.3 q/ha, maturity 144 days, 100-seed weight 20.45 g and tolerant to wilt.
Pant Gram 9 (PG 158)	Uttar Pradesh and Plains of Uttarakhand	Suitable for rainfed/irrigated, condition, yield of 17.3 q/ha, 100-seed weight 22.41 g, maturity 142 days and tolerant to wilt, and pod-borer.
Gujarat Kabuli Gram 1 (GJGK 1617)	Punjab, Haryana, North Rajasthan and Plains of Uttarakhand	Suitable for irrigated, condition, yield 13.8 q/ha, 100-seed weight 42.2 g, maturity 144 days and a bold seeded line with beige colour attractive seeds with a protein content of 18.01%, and moderate resistance against wilt.

Variety	Area of adoption	Salient features
CG Akshya Chana (RG 2016-134)	Karnataka, Tamil Nadu, Telangana and Andhra Pradesh	Suitable for the cultivation under irrigated, and timely-sown condition, yield 16.8 q/ha, protein content 18.74 (%), maturity in 94 days, and moderately resistant to wilt.
Samriddhi (IPCMB19-3)	Madhya Pradesh, Maharashtra and Gujarat	Suitable for irrigated, and timely-sown condition, yield 20.8 q/ha, protein content 22.9%, maturity 106 days, and *Fusarium* wilt resistant introgression line.
Pusa Chickpea 4005	Punjab, Haryana, Western Uttar Pradesh and Rajasthan	Suitable for *rabi*, timely-sown and rainfed conditions, yield 16.2 q/ha, protein content 17.17%, maturity 119 days, tolerant to abio tic stresses, drought, and medium bold, yellowish brown.
Karan Kabuli 4 (CSJK 174)	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for timely-sown condition in prevalent cropping system, higher seed yield 14.7 q/ha, medium maturity (99 days) and attractive beige-coloured medium-large seeds (32.13 g/100-seed weight).
Kota Kabuli Channa-3 (RKGK 13-414)	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan and Uttar Pradesh	Suitable for timely-sown and irrigated, condition, average yield 17.8 q/ha, maturity 110–115 days, medium tall (65 cm), semi-erect, single white flowers, medium bold, cream, wrinkled seed, and resistant to wilt.
Nandyal Gram 857 (NBeG 857)	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated, and timely-sown condition, yield 18.2 q/ha, maturity 90–105 days, protein content of 21.7%, high yielding desi chickpea and tolerant to wilt.
IPC 2010-134 (Shiva)	Uttar Pradesh	Suitable for irrigated, and timely-sown condition, yield 17.1 q/ha, maturity 124–138 days, and moderately resistant against fusarium wilt.
IPC 2007-28 (Atal)	Uttar Pradesh	Suitable for irrigated, and timely-sown condition, yield 16.9 q/ha, maturity 112–138 days, and resistant against fusarium wilt.
Sabour Chana-2	Bihar	Suitable for late-sown condition, yield 18–2 q/ha, maturity 120–125 days and 100-seed weight 14.5 g.
Keshav (GNG-2261)	Rajasthan	Suitable for late-sown irrigated, condition, yield 20.7 q/ha, maturity 128 days, protein content 21.09%, 100-seed weight 15.0 g and yellowish brown seed colour.
PBG 8 (GL 13042)	Punjab	Suitable for irrigated, condition, yield 21.0 q/ha, maturity 154–160 days and moderately resistant to botrytis grey mould, and *Fusarium* wilt diseases.
Phule Vishwaraj (Phule G-15109)	Maharashtra	Suitable for rainfed condition, yield 16.3 q/ha, maturity 95–105 days, 100-seed weight 22–23 g and protein content 22.91%.
Haryana Chana No. 6 (HC 6)	Haryana	Suitable for timely and late-sown conditions, yield 22.7 q/ha, maturity 147 days, 100-seed weight 17.0 g and protein content 21.76%.
Pigeon pea/Red gram (*Cajanus cajan*)		
Phule Damayanti (Phule Tur 0723-1-2-3)	Karnataka, Tamil Nadu, Andhra Pradesh, Odisha and Telangana	Suitable for rainfed and irrigated, conditions, yield 15.9 q/ha, maturity 175 days, moderately resistant to wilt and SM diseases, tolerant to *Helicoverpa*, *Maruca* and pod-fly, and high protein content (20.87%).
Rajendra Arhar 2 (DA 15-11)	Uttar Pradesh, Bihar, Jharkhand and West Bengal	Suitable for rainfed/irrigated, condition, yield 19.2 q/ha, maturity 247–257 days, resistant to wilt and sterility mosaic, moderately resistant to *Phytophthora* stem blight, root-knot nematode, cyst nematode and tolerant to *Helicoverpa,* and pod-fly.
Pulse Arhar 2018 -4	Punjab, Delhi, Haryana and Western Uttar Pradesh	Suitable for rainfed/irrigated, North West Plain Zone (NWPZ), yield 16.7 q/ha, maturity 121–150 days (early), maximum yield recorded 23.06 q/ha, early maturity with semi-erect compact indeterminate plant type, and 22.75% protein content in seed.
IPA 15-06	Gujarat, Maharashtra, Chhattisgarh and Madhya Pradesh	Suitable for *kharif*, rainfed Central Zone (CZ) conditions, yield 17.4 q/ha, maturity 149 days (early), bold seeded with mean 100-seed weight of 9.9 g, tolerant to *Phytophthora* blight, sterility mosaic disease, moderately resistant to *Fusarium* wilt and shown very less damage due to pod-fly and borer complex.
TDRG 59 (Telangana Kandi 3)	Karnataka, Andhra Pradesh, Telangana, Tamil Nadu and Odisha	Suitable for rainfed/irrigated, and timely-sown conditions of Southern Zone (SZ), yield 17.2 q/ha, protein content 22.86%, maturity 170–175 days, moderately resistant to wilt, sterility mosaic diseases, and less damage due to pod-borer and pod-fly under field conditions.

Variety	Area of adoption	Salient features
CG Arhar 2 (Savitri)	Chhattisgarh	Suitable for *kharif* rainfed and *rabi* irrigated, conditions, yield potential of 20.6 q/ha, medium maturity 170–180 days duration, indeterminate, compact, resistant to wilt, and moderately resistant to stem blight, *Macrophomina* blight and stem canker.
Gujarat Tur 106 (Mahi)	Gujarat	Suitable for *kharif* irrigated,/rainfed condition, yield 18.4 q/ha (middle Gujarat) and 18.5 q/ha (north Gujarat), high-yield potential, green stem and green foliage, yellow flower, green constricted pod having 4–6 seeds per pod, resistant to wilt, and moderately resistant to SMD under the natural field condition.
Birsa Arhar 2 (BAUPP 09-22)	Jharkhand	Suitable for rainfed condition, average grain yield 25–30 q/ha, protein content 22.48%, maturity 240–250 days, resistant to wilt and tolerant to pod-borer complex, and perform good under moisture stress.
BDN 2013-41 (Godawari)	Maharashtra	Suitable for *kharif* condition, yield 19.5–24.5 q/ha, maturity 160–165 days, resistant to wilt, SMD and white seeded.
WRG 255 (Warangal Kandi 2)	Telangana	Suitable for rainfed and irrigated, condition, average grain yield 16.0 q/ha, protein content 20.13%, high crude fibre (3.59%), Fe (41.01 ppm), Ca (349.56), maturity 170–180 days, both medium and black soils under rainfed conditions during *kharif,* and resistant to *Fusarium* wilt.
Cowpea (*Vigna unguiculata*)		
Pant Lobia 7 (PGCP 24)	Northern part of the country	Suitable for rainfed and irrigated, conditions, yield 11.0–12.0 q/ha, protein content 27%, maturity 70–75 days, and resistant to YMV.
Jammu Lobia Super 60	Jammu Province of Union Territory of Jammu and Kashmir	Suitable for rainfed, *kharif* season, yield 12.0–12.5 q/ha, maturity 60–65 days, resistant to wilt, YMV and pod-borer, and lodging resistant due to dwarf in stature.
PGCP 6	Karnataka	Suitable for early and late *kharif* sowing condition, yield 9.0–10.0 q/ha and early maturity (70–75 days).
KBC 11 (KC 8)	Karnataka	Suitable for late summer season, yield 11.0–12.0 q/ha, late maturity (95–100 days), medium duration, bold and light seed.
Sahyadri Yukthi (UAHS 28)	Karnataka	Suitable for late *kharif* and summer season of zone 4 and 7 of Karnataka, yield 12–13 q/ha, early maturity (80–85 days), short stature and grown well in limited moisture conditions.
PDKV Rutuja (AKCP 8-2-2)	Maharashtra	Suitable for *kharif* and summer season, pod yield 80–85 q/ha, protein content in pod 4.77%, maturity 45 days for first picking, and moderately resistant to yellow mosaic virus.
Horse gram (*Macrotyloma uniflorum*)		
Sabri Kulthi (BSP 17-3)	Chhattisgarh, Jharkhand, Rajasthan, West Bengal and Maharashtra	Suitable for rainfed, *kharif*, yield 17.0–18.0 q/ha, maturity 100–103 days, resistant to dry root-rot and yellow mosaic virus, and resistant to leaf-hopper and white-fly.
Alakh Kulthi (BSP 17-1)	Chhattisgarh, Jharkhand, Rajasthan, West Bengal and Maharashtra	Suitable for rainfed, *kharif*, yield 16.0–17.0 q/ha, maturity 100–105 days, protein content 26.1% and resistant to dry root-rot and YMV.
Anantha Vulava 1 (ATPHG 11)	Rajasthan, Maharashtra, West Bengal, Chhattisgarh and Jharkhand	Suitable for rainfed, *kharif*, yield 8.0–11.0 q/ha, maturity 105–110 days and highly resistant to dry root-rot, and moderately resistant to YMV.
Rajmash (*Phaseolus vulgaris*)		
Badwerwah Rajmash 104 (BR 104)	Union Territory of Jammu and Kashmir.	Suitable for temperate and high hill zone, seed yield 6.76 q/ha, maturity 127–132 days, moderate infection to anthracnose, and tolerant to angular leaf spot.
Sikkim Rajmash 1 (SKR 57A)	Sikkim	Suitable for rainfed, timely-sown for organic condition, average yield 10.0–12.0 q/ha, maturity 105 days, tolerant to bean common mosaic virus, angular leaf spot, leaf-miner, moderately tolerant to white-fly, aphid and moderately resistant to bean anthracnose, and collar rot.

Variety	Area of adoption	Salient features
Greengram/Mungbean (*Vigna radiata*)		
Phule Chetak (PM 707-5)	Maharashtra	Suitable for early maturing *kharif* cultivation, yield 10–12 q/ha, maturity 69 days, moderately resistant to major diseases (powdery mildew, MYMV) and tolerant to pod-borer.
Madhira Pesara 1 (MGG 385)	Telangana	Suitable for rainfed/irrigated, and timely-sown conditions, yield 12–13 q/ha, protein content 29.05%, maturity 70–75 days, less damage due to pod-borer and pod-fly under field conditions, resistant to leaf crinkle, leaf curl, and moderately resistant to YMV and pod-borer.
ML 1808	Punjab	Suitable for irrigated, conditions, yield 11–12 q/ha, maturity 70–75 days, resistant to yellow mosaic disease and medium sized shining grains with good culinary properties.
Rupohi (SGC 16 (AAU SGC 16)	Assam	Suitable for *kharif* season and rainfed condition, yield 12–13 q/ha, protein content 24.5%, maturity 65–68 days, resistant to CLS and MYMV and moderately resistant to pod-borer, leaf roller, and aphids.
Gujarat Anand Mungbean 8 (GAM 8: Hara Moti)	Gujarat	Suitable for summer season, yield 8–9 q/ha, protein 25.86%, maturity 65–70 days, resistant against MYMV, powdery mildew, ULCV and *Anthracnose* and moderately resistant to CLS, web blight, *Macrophomina* blight, whitefly, defoliators, and pod-borer.
JAUM 0936	Jammu province of UT of Jammu and Kashmir	Suitable for Jammu province, yield 10–12 q/ha, protein content 23.35%, maturity 60–62 days, resistant to YMV, LCV and pod-borer.
Shalimar Moong 3	UT of Jammu and Kashmir	Suitable for Kashmir valley, yield 9–10 q/ha, maturity 100–110 days, resistant to cowpea mosaic virus and moderately resistant to *Cercospora* leaf spot, and aphid.
VBN 5 (VGG 15 013)	Tamil Nadu	Suitable for all seasons, yield 8–9 q/ha, maturity 70–75 days, resistant to mungbean yellow mosaic virus and urdbean leaf crinkle virus diseases.
Urdbean/blackgram *(Vigna mungo*)		
Pant Urd 12	Uttar Pradesh, Punjab, Haryana, Rajasthan, Delhi, Uttarakhand and Jammu and Kashmir	Suitable for rainfed/irrigated, conditions of *kharif* season, yield 14.3 q/ha, maturity 79 days, resistant against MYMV, web blight, leaf crinkle, leaf curl virus and root-rot diseases, white- fly, pod-borer, pod bug, maruca, and pod-fly.
Kalinga Urd 41 (OBG 41)	Odisha, Andhra Pradesh, Tamil Nadu and Karnataka	Suitable for rainfed condition, average yield 11.0 q/ha maturity 72 days, resistant against MYMV, leaf crinkle virus, CLS and moderately resistant to web blight, powdery mildew, *Macrophomina* blight, anthracnose, and root-rot diseases.
Kota Urd 5 (KPU 52-87)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Odisha	Suitable for normal sown *kharif* season, yield 16.50 q/ha, maturity 74 days, moderately resistant to MYMV, *Cercospora* leaf spot (CLS), powdery mildew, web blight, anthracnose, exhibited less incidence of aphids, defoliators, bod-borer and pod bug.
Mash 1137	Punjab	Suitable for timely-sown during *kharif* season in entire Punjab, average grain yield 10–12 q/ha, protein 24.16%, maturity 73–74 days, resistant to diseases and insect-pests (the variety possesses multiple disease resistance), highly resistant to mungbean yellow mosiac virus, urdbean leaf crinkle virus, leaf curl virus, web blight, bacterial leaf blight, powdery mildew, *Cercospora* leaf spots, white-fly, pod-borer, pod bug insects under field conditions, and moderately resistant against root knot nematodes.
IPU 17-1	Madhya Pradesh	Suitable for timely-sown condition, average grain yield 10–12 q/ha, maturity 73–74 days, moderately resistant against root knot nematodes and resistant to urdbean leaf crinkle virus, leaf curl virus, web blight, bacterial leaf blight, powdery mildew, *Cercospora* leaf spot, and white-fly, pod-borer, pod bug insects under field conditions.
CO 7 (COBG 10-05)	Tamil Nadu	Suitable for single/mechanical harvest, average yield 8–10 q/ha, 22.3% protein, maturity 60–65 days, resistant to YMD and moderately resistant to leaf crinkle, and stem necrosis diseases.
Blackgram LBG 791	Karnataka	Suitable for rainfed upland ecology and timely-sowing condition, yield 12.2 q/ha, maturity 79–85 days, resistant to MYMV, *Cercospora* leaf spot, root-rot, powdery mildew and moderately resistant to white-fly, jassid, and root knot nematode.

Variety	Area of adoption	Salient features
Birsa Urd 2 (RUB 12-02)	Jharkhand	Suitable for rainfed upland land ecology and timely-sowing condition, grain yield 12.2 q/ha, maturity 79–85 days, resistant to MYMV, *Cercospora* leaf spot, root-rot, powdery mildew, and moderately resistant to white-fly, jassid and root knot nematode.
Shyamal (SBC 40 (AAU SBC 40)	Assam	Suitable for *kharif* season under rainfed condition, yield 14–16 q/ha, protein content 25.2%, maturity 75–80 days, resistant to *Cercospora* leaf spot (CLS), yellow mosaic virus (MYMV) diseases and moderately resistant to pod-borer, aphids, leaf-roller, and storage pests.
Gujarat Anand Urd bean 4 (GAU 4: Shyamal)	Gujarat	Suitable for *kharif* and summer season, yield *(kharif)* 10–11.0 q/ha, protein content 24.66%, maturity 80–85 days, resistant to yellow mosaic disease under natural field condition, sucking pests, viz. whitefly, aphid, thrips and pod-borer infestation was low.
Lentil (*Lens culinaris*)		
Jammu Lentil 144	Jammu Province of Jammu and Kashmir	Suitable for rainfed areas of Jammu region, lodging resistant, average yield 11–12 q/ha, seeds having high protein content (22%) and maturity 122–125 days.
Jammu Lentil 71	Jammu Province of Jammu and Kashmir	Suitable for rainfed areas of Jammu region, average yield 10–11 q/ha, seeds having high protein content (24%), maturity 140–145 days, resistant to wilt, root-rot, pod-borer, aphids, and lodging due to dwarf stature.
Bidhan Lentil 16	West Bengal	Suitable for old and new Alluvial zones of West Bengal, Bankura, Birbhum, Purulia, West Midnapur and in areas of P (Phosphate) deficient soils, recommended variety for *rabi* pulse and also suitable for vast rice fallow due to its heat tolerance ability, yield 15.5 q/ha, and maturity 109–132 days.
Field pea (*Pisum sativum*)		
IPFD 16-3	Uttar Pradesh	Suitable for irrigated, as well as rainfed conditions during *rabi* season, yield 16–17 q/ha, duration 115–125 days, resistant to powdery mildew, rust and *Ascochyta* blight disease, exhibit less incidence of pod-borer, and leaf-miner.
Faba bean (*Vicia faba*)		
HFB 2	Haryana, Punjab, Uttar Pradesh and Chhattisgarh	Suitable for irrigated/timely-sown condition, grain yield 25.2 q/ha, maturity 131–143 days, moderately resistant to *Alternaria* leaf blight and root-rot diseases, protein content 24.13%, seed hilum black, and greenish brown colour.
Cluster bean (Guar) (*Cyamopsis tetragonoloba*)		
Gujarat Guar 3 (Banas Uday)	Gujarat	Suitable for *kharif* in arid regions, yield under normal condition 13–14 q/ha, maturity 98–100 days, early maturing group, lesser infestation against bacterial leaf blight, white-fly and leaf-hopper, and gum content 29.40%.
Broad bean (*Vicia faba*)		
SJBB 01	Jammu and Kashmir	Suitable for sub-tropical and mid-hill zone, yield 80–100 q/ha, maturity 95 –100 days, erect type, direct sown, tolerant to major diseases and insect-pests prevalent in the region.
Winged bean (*Psophocarpus tetragonolobus*)		
PWB 11-2 (Phule Chardhari Wal)	Maharashtra, Chhattisgarh and Jharkhand	Suitable for irrigated, condition, average green pod yield 130.67 (q/ha), average seed yield 12.9 q/ha, maturity 177 days and 50% flowering 74 days.

Commercial crops: Ninety eight high-yielding varieties/ hybrids of commercial crops including 83 of cotton, 14 of sugarcane and 1 of jute were released for different agro-ecological regions.

List of improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Salient features
Cotton (*Gossypium* spp.)		
RS 2827	Rajasthan, Punjab and Haryana	Suitable for timely-sown irrigated, condition, yield 30.5 q/ha, maturity 165–175 days, par tolerance with checks against white-fly, leaf-hopper and cotton boll worm complex, resistant to showed relatively better disease reactions (tolerance) against CLCuD, and BLB (bacterial leaf blight).

Variety	Area of adoption	Salient features
RS 2818	Rajasthan, Punjab and Haryana	Suitable for timely-sown irrigated, condition, yield 30.9 q/ha, maturity 165–175 days, par tolerance with checks against white-fly, leaf-hopper and cotton boll worm complex, resistant to better disease reactions (tolerance) against CLCuD, and BLB (bacterial leaf blight).
Suvarna Shubhra (AKH 09-5)	Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Odisha	Suitable for rainfed, timely-sown condition in *kharif* season, yield (rainfed) 13.0–16.0 q/ha, maturity 150–160 days, tolerant to jassids, *Myrothecium* leaf spot, grey mildew, and bacterial leaf blight diseases.
PBH 116	Punjab, Haryana and Rajasthan	Suitable for north zone, yield 29.5 q/ha, maturity 160–170 days, fibre was comparable with all checks and qualifying variety.
Nandyal Cotton 22 (NDLH 2005-4)	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan and Odisha	Suitable for rainfed condition, seed-cotton yield 15.7 q/ha, maturity 160 days, moderately tolerant to sucking pests like jassids, tolerant to bacterial leaf blight, *Myrothecium* leaf spot, *Alternaria* leaf spot, and grey mildew.
Nandyal Cotton 23 (NDLH 2028-2)	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, yield 13.2 q/ha, maturity 150–155 days, resistant to diseases and insect pests, moderately tolerant to bacterial leaf blight, *Alternaria* and grey milder diseases, jassids, lower boll damage due to pink bollworm and tolerant to abiotic stresses, and drought.
Nandyal Cotton 24 (NDLH 2051-1)	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan and Odisha	Suitable for rainfed condition, maturity 160 days, moderately tolerant to sucking pests like jassids and tolerant to bacterial leaf blight, *Alternaria* leaf spot and grey mildew.
Phule JLA 1110	Andhra Pradesh, Telangana, Tamil Nadu and Karnataka	Suitable for rainfed condition, yield 13.7 q/ha, maturity 170–180 days, resistant to bacterial leaf blight, moderately susceptible to *Alternaria* leaf blight and grey mildew and moderately resistant to sucking pests, and bollworms.
CICR-H Cotton 47 (CNH 1111)	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan and Odisha	Suitable for rainfed condition, yield 14.1 q/ha, maturity 150–165 days and tolerant to jassids.
CICR-H Cotton 48 (CNH 1128)	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, yield 14.0 q/ha, maturity 150–165 days and tolerant to jassids.
CICR-H NC Cotton 53 [ICAR-CICR 16301 DB (Vaidehi 1)]	Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	Suitable for rainfed condition, yield 15.0 q/ha, maturity 160–165 days and tolerant to sucking pests.
DSC 1651	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for rainfed condition, yield 16.9 q/ha, maturity 145–160 days and compact variety.
ARBC 1651	Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Odisha, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	Suitable for rainfed condition, yield 16.3 q/ha, maturity 140–160 days, compact variety and tolerant to jassids.
CPD 1652	Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Odisha	Suitable for rainfed condition, yield 17.8 q/ha (CZ), average yield 15.3 q/ha (SZ), maturity 170–180 days, tolerant to bacterial leaf blight, grey mildew and jassids.
ARBH 1551	Maharashtra, Madhya Pradesh, Gujarat, Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	Suitable for rainfed condition, yield 16.1 q/ha (CZ) and 15.3 q/ha (SZ), maturity 170–180 days, tolerant to BLB, jassids, and whitefly.
PA 810	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan and Odisha	Suitable for rainfed condition, yield 11–12 q/ha, maturity 150–160 days, tolerant to sucking pests, bacterial blight, *Alternaria* and grey mildew.
CICR-A Cotton 46 (CNA 1054)	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan and Odisha	Suitable for rainfed condition, yield 14.0 q/ha, maturity 150–160 days and tolerant to jassids.

Variety	Area of adoption	Salient features
DB 1601	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 14.8 q/ha, maturity 160–170 days, moderately resistant to bacterial leaf blight and grey mildew.
CO 18 (TCB 37)	Gujarat, Maharashtra, Madhya Pradesh and Odisha.	Suitable for irrigated, condition, yield of 8.3 q/ha bacterial leaf blight and *Alterneria* leaf blight/spot.
ARBHB -1602	Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, conditions of SZ and CZ States, seed-cotton yield 15.9 q/ha (SZ) and 12.8 q/ha (CZ), lint yield 5.4 q/ha (SZ) and 4.3 q/ha (CZ), maturity (medium) 170–180 days, highest boll weight and very high GOT%, resistant to BLB, grey mildew, moderately resistant to *Alternaria* leaf blight and rust diseases, moderately tolerant to leaf-hoppers and showed lesser whitefly, thrips and aphids infestation than in the other entries, greater tolerance to pink boll-worm and *Helicoverpa.*
ARBC 1601	Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Odisha	Suitable for irrigated, condition, yield 19.6 q/ha, maturity 145–165 days, compact variety, tolerant than the checks to bacterial blight and *Myrothecium*.
ARBB 1502	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, condition, average yield 9.8 q/ha, maturity 160–170 days and tolerant to jassids.
CICR B Cotton 45 (CCB 143B)	Tamil Nadu, Andhra Pradesh and Karnataka	Suitable for irrigated, condition, average yield, 14.6 q/ha and maturity 166–170 days.
ARBHB-1601	Karnataka, Andhra Pradesh, Telangana and Tamil Nadu	Suitable for irrigated, condition, average yield 20.0 q/ha, maturity 180–190 days, moderately resistant to bacterial leaf blight, grey mildew and rust.
Gujarat Anand Desi Cotton 4 (Wagad Resham)	Gujarat	Suitable for rainfed condition, organic, long-staple varietal cultivation, yield 14.0 q/ha, lint yield 5.0 q/ha, first ever long staple (UHML 29.4 mm) and open boll type herbaceum cotton variety.
PA 837	Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for rainfed condition, yield 15.3 q/ha, maturity 150–160 days, tolerant to bacterial blight and *Alternaria* leaf spot, tolerant to sucking pests, long-linted arbore tum, superior fibre length, strength and spinning counts.
KR-136	Haryana, Rajasthan and Punjab	Suitable for irrigated, condition, yield 35.1 q/ha, maturity 160–165 days, resistant to fungal foliar disease and BLB, and non-pinnable desi hybrid.
LHDP Cotton 5	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 24.1 q/ha, maturity 140–150 days, moderately tolerant to BLB and ALS, tolerant to sucking pests and compact variety suitable for HDPS.
GISV 312 GN.Cot.44	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed condition, yield 15.9 q/ha, maturity 160–180 days, resistant to BLB, ALS, moderately resistant to GM, tolerant to sucking pests and compact variety suitable for HDPS.
PBH 115	Punjab, Haryana and Rajasthan	Suitable for irrigated, condition, yield 29.7 q/ha, maturity 160–165 days, moderately resistant to CLCuD, resistant to FFLS, BLB, tolerant to jassids and compact variety suitable for HDPS.
CICR-A Cotton 56 (CNA1031)	Maharashtra, Gujarat, Madhya Pradesh and Odisha	Suitable for rainfed condition, yield 13.6 q/ha, maturity 150–160 days, tolerant to lodging and good locule retention.
CICR-A NC Cotton 57 (CNA 1091)	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, yield 12.4 q/ha, maturity 150–160 days, tolerant to lodging, good locule retention and naturally coloured cotton.
CICR-H NC Cotton 58 (CNH 17395)	Karnataka, Telangana, Andhra Pradesh and Tamil Nadu	Suitable for irrigated, and rainfed condition, yield 20.0 q/ha, maturity 160–165 days, resistant to ALS, GM BLB, moderately resistant to CLS and rust naturally colored cotton.
CICR-A NC Cotton 59 (CNA17522)	Gujarat, Madhya Pradesh and Maharashtra	Suitable for rainfed condition, yield 11.2 q/ha, maturity 160–165 days, moderately resistant to lodging and shattering, and naturally coloured cotton.
CICR-H cotton 54 (Nano)	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh, Gujarat and Odisha	Suitable for irrigated,/rainfed condition, yield 21.2 q/ha, maturity 130–140 days, resistant to BLB, ALS, MLS, rust, moderately resistant to GM and immune to root-rot, and compact variety suitable for HDPS.

Variety	Area of adoption	Salient features
SBSG 1-5 (SIMA Platinum)	Gujarat, Maharashtra, Madhya Pradesh and Odisha	Suitable for irrigated, condition, yield 10.6 q/ha, maturity 160–165 days and ELS variety.
Bt Cotton		
NC 369 Bt2	Gujarat, Maharashtra and Madhya Pradesh	Suitable for rainfed condition, yield 10.8 q/ha, maturity 140–150 days, resistant to bacterial leaf blight and resistant to ALS, grey mildew under unprotected rainfall condition, resistant to BLB, ALB, FFS, GM, CLS and MSL.
NCS 2778 Bt2	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra	Suitable for rainfed condition, yield 17.3 q/ha, maturity 140–150 days, moderately resistant to bacterial leaf blight, grey mildew under unprotected rainfall condition, resistant to BLB, ALB, FFS, GM, CLS and MSL.
G. Cot. Hy-26 (BG-II: Sorathswet Kanchan)	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, ecosystem, yield 19.7 q/ha and maturity 160–170 days.
PAU Bt 1	Punjab and Rajasthan	Suitable for North Zone, yield 27.2 q/ha and maturity 160–165 days.
PAU Bt 2	Punjab, Haryana and Rajasthan	Suitable for North Zone, yield 29.1 q/ha and maturity 160–165 days.
C 9333 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, ecosystem, yield 19.1 q/ha and maturity 160–170 days.
C 9313 BG II	Punjab, Haryana and Rajasthan	Suitable for irrigated, ecosystem, yield 36.9 q/ha and maturity 160–165 days.
C 366 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, ecosystem, yield 20.7 q/ha and maturity 150–160 days.
C 9344 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, ecosystem, yield 20.0 q/ha and maturity 170–180 days.
C 352 BG II	Punjab, Haryana and Rajasthan	Suitable for irrigated, ecosystem, yield 37.6 q/ha and maturity 160-165 days.
C 363 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, ecosystem, yield 19.8 q/ha and maturity 160–170 days.
C 344 BG II	Gujarat	Suitable for rainfed ecosystem, yield 22.7 q/ha, maturity 150–160 days.
C 9397 BG II	Gujarat	Suitable for rainfed ecosystem, yield 20.4 q/ha, maturity 160–170 days.
C 9391 BG II	Gujarat	Suitable for rainfed ecosystem, yield 17.6 q/ha and maturity 150–160 days.
C 331 BG II	Gujarat	Suitable for rainfed ecosystem, yield 20.6 q/ha, maturity 150–160 days.
Solar 106 BG II	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, ecosystem, yield 18.4 q/ha and maturity 155–160 days.
Solar 108 BG II	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, ecosystem, yield 19.1 q/ha and maturity 160–165 days.
ICAR-CICR Bt 9 (ICAR-H Bt Cotton 49)	Maharashtra	Suitable for rainfed ecosystem, yield 29.3 q/ha and maturity 150–170 days.
ICAR-CICR Bt 14 (ICAR-H Bt Cotton 50)	Maharashtra	Suitable for rainfed ecosystem, yield 27.0 q/ha and maturity 160–170 days.
ICAR-CICR Bt 21 (ICAR-H Bt Cotton 51)	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed ecosystem, yield 10.0 q/ha and maturity 150–160 days.
ICAR-CICR Bt 25 (ICAR-H Bt Cotton 52)	Tamil Nadu, Karnataka, Telangana and Andhra Pradesh	Suitable for rainfed ecosystem, yield 15.8 q/ha and maturity 150–160 days.
VSCH 369 BG II	Maharashtra, Madhya Pradesh, Gujarat, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated,/rainfed, yield 21.4 q/ha (CZ-I), 26.3 q/ha (SZ-I) and 19.3 q/ha (SZ-R).

Variety	Area of adoption	Salient features
VSCH 234 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed condition, yield 19.3 q/ha, maturity 145–150 day, tolerant to lodging and shattering.
ARCH 3001 BG II	Madhya Pradesh, Maharashtra and Gujarat	Suitable for irrigated, and rainfed condition, yield 19.7 q/ha (I); 15.15 q/ha (R) and maturity 165–175 days.
ARCH 3106 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 25.3 q/ha and maturity 160–170 days.
Panchaganga ZCH 1439 BG II Pradhan	Maharashtra, Madhya Pradesh and Gujarat	Suitable for irrigated, condition, yield 20.5 q/ha and maturity 160 days.
Shiva MC 5444 BG II	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated, condition, yield 21.0 q/ha and maturity 150–165 days.
Vrishti MC 5441 BG II	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Madhya Pradesh, Maharashtra and Gujarat	Suitable for irrigated,/rainfed condition, yield 20.0 q/ha (I), 18.8 q/ha (R) and maturity 150–165 days.
DAMAK MC 5459 BG II	Madhya Pradesh, Maharashtra and Gujarat	Suitable for rainfed condition, yield 18.0 q/ha and maturity 150–160 days.
RCH 960 BG II	Punjab, Haryana, Rajasthan, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 35.7 q/ha and maturity 160–170 days.
RCH 971 BG II	Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 19.1 q/ha (CZ); 24.7 q/ha (SZ) and maturity 150–160 days.
KCH 9323 BG II	Haryana, Punjab and Rajasthan	Suitable for irrigated, condition, yield 36.1 q/ha, maturity 160–170 days and highly resistant to CLCuD.
KCH 9292 BG II	Andhra Pradesh, Karnataka, Tamil Nadu, Telangana, Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated, condition, yield 20.9 q/ha (CZ); 26.0 q/ha (SZ), maturity 160–165 days, resistant to bacterial leaf blight, Alternaria leaf spot and grey mildew.
NBC 2020 BGII	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated, condition, yield 23.0 q/ha and maturity 140–150 days.
ACH 909-2 BG II	Maharashtra, Gujarat and Madhya Pradesh	Suitable for rainfed condition, yield 17.9 q/ha and maturity 145–155 days.
ACH 52-2 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 26.0 q/ha and maturity 150–160 days.
Mahabeej 124 BG II	Maharashtra	Suitable for rainfed condition, yield 25.0 q/ha and maturity 150–160 days.
ATCH 118 BG II	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated, condition, yield 22.7 q/ha and maturity 150–60 days.
KCH 9333 BG II	Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated, condition, yield 36.2 q/ha and maturity 160–170 days.
GBCH 1801 BG II	Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	Suitable for irrigated, and rainfed conditions, yield 19.3 q/ha (I); 16.4 q/ha (R) and maturity 140–165 days.
US 704 BG II	Andhra Pradesh, Karnataka, Telangana, Tamil Nadu, Maharashtra, Gujarat and Madhya Pradesh	Suitable for irrigated, and rainfed conditions, yield 21.4 q/ha (C-I); 18.1 q/ha (C-R), 24.7 q/ha (S-I); 19.9 q/ha (S-R) and maturity 160–165 days.

Variety	Area of adoption	Salient features
Neo 1656 BG II	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed condition, yield 15.1 q/ha and maturity 145–150 days.
CICR-H Bt Cotton 60 (Yogank Bt (CICR 183059-5)	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed condition, yield 12.7 q/ha and maturity 140–150 days.
CICR-H Bt Cotton 61 (Tejas Bt (Bt 183059-4)	Maharashtra, Madhya Pradesh and Gujarat (Rainfed conditions)	Suitable for rainfed condition, yield 11.6 q/ha and maturity 140–150 days.
CICR-H Bt Cotton 62 Namami (CICR 19-32 BT)	Maharashtra, Madhya Pradesh and Gujarat	Suitable for rainfed condition, yield 11.5 q/ha and maturity 140–150 days.
CICR-H Bt Cotton 63 (Samart Bt (CICR 183059-2)	Karnataka, Tamil Nadu, Andhra Pradesh and Telangana	Suitable for rainfed condition, yield 13.7 q/ha and maturity140–150 days.
Indam 1634 BG II	Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for irrigated, condition, yield 18.4 q/ha, maturity140–160 days and ELS HxB.
Bidhan Pat 13 (BCCO 13)	West Bengal	Suitable for upland and medium lands for sowing in mid-March to mid-April, yield 32.0 q/ha, fibre maturity 120 days, seed maturity 170–175 days, and fine fibre variety (fineness 2.96 tex).
Sugarcane (*Saccharum* spp.)		
CoVC 16061	Karnataka	Suitable for irrigated, areas of Southern Karnataka in wide row planting, cane yield of 140–150 tonnes/ha, early maturing (10 months), resistant to leaf spot and grassy shoot disease, and moderately resistant to yellow leaf disease. Less susceptible to early and top shoot-borer, moderately susceptible to internode-borer and drought tolerant.
CoLK 14204 (Ikshu 8)	Punjab, Haryana, Uttarakhand, Rajasthan, Central and Western Part of Uttar Pradesh	Suitable for irrigated, normal condition, cane yield 92.73 tonnes/ha, maturity mid-late (12 months), resistant to moderately resistant reaction against the two prevailing races Cf 08 and Cf 09, smut disease, less susceptible to major insect-pests of the sub-tropical zone, tolerant to drought and water-logging.
CoPb 98 (CoPb 14185)	Punjab, Haryana, Rajasthan, Uttarakhand and Western and Central Uttar Pradesh	Suitable for irrigated, and timely-sown conditions, cane yield 88.99 tonnes/ha, maturity mid-late (300 days), moderately resistant to red-rot, less susceptible to top- borer, non-lodging and frost tolerant.
Rajendra Ganna 2 (CoP 09437)	Uttar Pradesh, Bihar, Assam and West Bengal	Suitable for irrigated, timely-sown conditions, cane yield 77.68 tonnes/ha, mid-late maturing variety (12 months), 17.60% sucrose in juice, resistant to red-rot, smut and wilt under artificial inoculation and low insect-pests-incidence during the crop period.
Ikshu-10 (COLK 14201)	Uttar Pradesh	Suitable for irrigated, normal condition, cane yield 87.26 tonnes/ha, maturity early (harvesting time at 12 months of crop age), resistant to diseases and insect-pests, resistant to moderately resistant at all test centers for red-rot and smut and less susceptible to the major insect-pests of the sub-tropical zone in most of the locations, tolerant to drought and water-logging.
CoPb 96	Punjab	Suitable for irrigated, condition, cane yield 90.56 tonnes/ha, maturity 240 days, tolerant against diseases (red-rot, wilt, smuts, pokkah boeng and YLD) and less susceptible against borer complexes.
CoPb 95	Punjab	Suitable for irrigated, condition, cane yield 94.71 tonnes/ha, maturity 8–10 months, moderately susceptible to red-rot pathotype CF 08 and CF 09 under artificial inoculation by plug method, resistant under artificial inoculation by nodal/cotton swab method, exhibited moderately resistant smut reaction (artificial inoculation by steeping method), less susceptible to borer complex (shootborer, topborer and stalkborer), and tolerant to frost.
Kalinga Sugarcane 346	Odisha	Suitable for irrigated, uplands and medium lands, could also be grown in rice land with proper water management during the growth season, average yield 112.66 tonnes/ha, maturity 300 days, resistant to ESB, IB and scale insects, resistant/tolerant to red-rot, tolerant to waterlogging and moisture stress.

Variety	Area of adoption	Salient features
CoVC 16062	Karnataka	Suitable for wide-row planting and high-tillering potential, yield 170–180 tonnes/ha, maturity 12–14 months, tolerant to moisture stress situation, resistant to leaf spot and grassy shoot disease and moderately resistant to yellow leaf disease. Less susceptible to early and top shootborer and moderately susceptible to internode-borer.
Phule 09057 (CoM 12085)	Maharashtra	Suitable for suru planting in medium deep black and lateritic red soils in Maharashtra, cane yield 156.23 tonnes/ha, CCS yield 23.03 tonnes/ha and jaggery 17.61 tonnes/ha, maturity mid-late (12 months), resistant (R) to smut, moderately susceptible (MS) to red-rot, moderately resistant (MR) to wilt, foliar diseases, less susceptible to internode borer, top shootborer and scale insect and moderately susceptible to early shootborer, and suitable for jaggery purpose.
Co 14012 (Avani)	Tamil Nadu, Kerala, Interior Andhra Pradesh, Telangana, Karnataka, Gujarat, Maharashtra and Madhya Pradesh	Suitable for growing under medium and high fertile soils of Peninsular zone of India under irrigated, condition, tolerant to drought, yield 109.82 tonnes/ha, maturity mid-late (360 days), moderately resistant to red-rot, resistant to smut and YLD, non-flowering and good ratooner.
CoLk 15201 (Ikshu 11)	Punjab, Haryana, Uttarakhand, Rajasthan, Central and Western Parts of Uttar Pradesh	Suitable for irrigated, condition, yield 93.92 tonnes/ha, early maturity (300 days), moderately resistant to red-rot and smut, non-lodging, non-flowing and better ratooning variety.
CoLk 15466 (Ikshu 13)	Eastern Part of Uttar Pradesh, Bihar, Jharkhand, West Bengal and Assam	Suitable for normal condition, excellent performance under water logged condition, yield 85.97 tonnes/ha, maturity early (300 days), moderately resistant to red-rot and smut, non-lodging, non-flowering and better raooning variety.
CoLk 15207 (Ikshu 12)	Punjab, Haryana, Uttarakhand, Rajasthan, Central and Western Parts of Uttar Pradesh	Suitable for irrigated, condition, yield 84.53 tonnes/ha, mid-late maturity (360 days), moderately resistant to red-rot and smut, non-lodging, non-flowering and better ratooning variety.

Forage and other crops: Twenty nine high yielding varieties/hybrids of forage and other crops comprising 7 of oat, 5 of berseem, 4 of forage pearl millet, 3 each of forage sorghum and maize, 2 of forage cowpea and 1 each of napier bajra hybrid, buckwheat, quinoa, asalio and white clover were released for cultivation in different agro-ecologies.

List of improved released varieties/hybrids of forage other crops

Variety	Area of adoption	Salient features
Forage crops		
Oats (*Avena sativa*)		
HFO 611	Rajasthan, Haryana, Punjab and Terai Part of Uttarakhand	Suitable for timely-sown, normal fertility and irrigated, conditions, green-fodder yield 160.7 q/ha, dry-matter yield 28.9 q/ha, high seed yield (25.2 q/ha), maturity – first cut in 60 days after sowing, harvesting for seeds after 90 days after first cut, better nutritional quality, and moderately resistant to *Helminthosporium* leaf blight disease.
HFO 529	Himachal Pradesh, Uttarakhand and Jammu and Kashmir	Suitable for timely-sown, normal fertility and irrigated, conditions, green -fodder yield 274.4 q/ha and dry-matter yield 70.6 q/ha, high seed yield (24.2 q/ha), seed maturity 150–160 days, better nutritional quality, and moderately resistant to powdery-mildew disease.
JO 10-506	Assam, Odisha, Jharkhand and eastern Uttar Pradesh	Suitable for irrigated, condition, green-fodder yield 225–250 q/ha, dry-matter yield 37–42 q/ha, seed yield 9–11 q/ha, maturity 135–145 days, resistant to lodging, moderately resistant to leaf blight, root*-rot and less preferred by aphid.
JO 05-304 (Multi cut)	Uttar Pradesh, Maharashtra and Gujarat	Suitable for rainfed/irrigated, condition under normal fertility, green-fodder yield 225–250 q/ha, dry-matter yield 37–42 q/ha, seed yield 9–11 q/ha, maturity 130–140 days, moderately resistant to leaf blight, root-rot and less preferred by aphid.

Variety	Area of adoption	Salient features
HFO 707	Uttarakhand, Punjab, Haryana and Rajasthan	Suitable for timely-sown, normal fertility and irrigated, conditions, multicut, green-fodder yield 696.1 q/ha, dry-matter yield 134.8 q/ha, seed yield 23.8 q/ha, first cut at 65 days after sowing and second cut at 50% flowering (50–60 days after first cut), 150–160 days seed-to-seed maturity, and moderately resistant against *Helminthosporium* leaf spot.
HFO 806	Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Telangana, Tamil Nadu, Kerala, Karnataka and Andhra Pradesh	Suitable for timely-sown, normal fertility and irrigated, conditions, single cut, South Zone - green-fodder yield 376.4 q/ha, dry-matter yield 83.9 q/ha, seed yield 9.5 q/ha; Hill Zone - green-fodder yield 295.2 q/ha, dry-matter yield 71.6 q/ha, seed yield 23.9 q/ha, first cut at 50% flowering, viz. 75–80 days after sowing, seed to seed maturity 140 days, good in nutritional quality, and moderately resistant against powdery mildew.
OL 1874-1	Telangana, Tamil Nadu, Kerala, Andhra Pradesh and Karnataka	Suitable for irrigated, *rabi* season, single cut variety, green-fodder yield 368.0 q/ha, dry-matter yield 81.3 q/ha, maturity 154 days (seed to seed), crude protein 8.4%, and moderately resistant to leaf blight.
Forage sorghum (*Sorghum bicolor*)		
CSV 46F (Tapi Chari)	Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh and Uttarakhand	Suitable for rainfed condition during *kharif* season, green-fodder yield 596.4 q/ha and dry-fodder yield 163.4 q/ha, days to 50% flowering 76–80, days to maturity 125–138, late maturity, single-cut forage sorghum, less HCN content (81.32 ppm), less infestation of shootfly (38.70% DH) and stem-borer (13.62% DH), tolerant to major leaf disease, viz. anthracnose, leaf blight, zonate leaf spot, grey-leaf spot, rust, Mold-PGS and Mold-TGS.
Jaicar Chari CSV 47F (SPV 2593)	Maharashtra, Tamil Nadu and Karnataka	Suitable for rainfed/irrigated, and timely-sown conditions, green-fodder yield 430.0 q/ha, dry-fodder yield 122.0 q/ha, days to 50% flowering 76; days to maturity 110–115, medium maturity, single-cut forage sorghum, protein 7.3%, IVDMD 47%, resistant to anthracnose and zonate leaf spot diseases, and tolerant to shootfly and stem-borer.
CSH 46MF (Fat Boy)	Gujarat, Haryana, Punjab, Uttarakhand, Uttar Pradesh and Rajasthan	Suitable for irrigated, summer and *kharif*, green-fodder yield 916.0 q/ha, dry-fodder yield 219.0 q/ha, maturity (seed to seed) 110–120 days, high protein content (7.9%), high digestibility (51%) with low HCN, moderately resistant to foliar diseases and stem-borer.
Forage pearl millet (*Pennisetum glaucum*)		
Telangana Fodder Bajra (TSFB 17-7)	Tamil Nadu, Karnataka and Telangana	Suitable for rainfed in *kharif* season and irrigated, dry crop during summer seasons, green-fodder yield 404.6 q/ha, seed yield 11.0 q/ha, maturity 110–120 days (seed to seed), crude protein content 10.5% and crude protein yield 9.3 q/ha, ADF 48.7%, NDF 72.3%, IVDMD 15.9%, palatable and digestible, resistant to leaf blast, downy mildew and leaf defoliators.
Telangana Multicut Bajra (TSFB 18-1)	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, dry crop during summer in red soil with medium fertility and black soils, fodder yield 860.0 q/ha, seed yield 11.3 q/ha, maturity 110–120 days (seed to seed), crude protein content 10.5%, crude protein yield 9.5 q/ha, ADF 39.9%, NDF 66.6%, IVDMD 57.8, no incidence of insect and diseases were observed.
BAIF Bajra 5	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, condition, fodder yield 882.2 q/ha, seed yield 11.4 q/ha, maturity 120–125 days (1st cut in 55–60 days, sub-sequent cut after 30 days of previous cut), no disease and pest were observed.
BAIF Bajra 6	Gujarat, Maharashtra and Madhya Pradesh	Suitable for irrigated, condition, fodder yield 909.9 q/ha, seed yield 11.0 q/ha, maturity 120–125 days (1st cut in 55–60 days and subsequent cut after 30 days of previous cut), no disease and pest were observed.
Forage maize (*Zea mays*)		
J 1007 (PFM 10) (Fodder)	Punjab	Suitable for all fodder growing irrigated, areas, green-fodder yield 421.0 q/ha, dry-matter yield 90.0 q/ha, seed yield 18.2 q/ha, seed to seed maturity 92 days, moderately susceptible to maydis leaf blight and maizeborer.
CG Makka Chari 1 (IAFM 2015-48)	Chhattisgarh	Suitable for rainfed and irrigated, medium fertility condition, fodder yield 345.2 q/ha, maturity 90–95 days (seed to seed) and 50–55 days (green-fodder), resistant to moderately resistant toleaf blight, banded leaf, stem-borer, high crude protein (7.92%), low ADF (39.2%), low NDF (61.5%) and high IVDMD (59.1%).

Variety	Area of adoption	Salient features
Shalimar Fodder Maize 1 (KDFM-1)	Union territory of Jammu and Kashmir	Suitable for rainfed maize growing areas of Jammu and Kashmir up to 2,200 m above mean sea level (AMSL), fodder yield 430–450 q/ha, maturity 75–80 days (green-fodder), 125–130 days (seed), tolerant to moisture stress, high crude protein and lower ADF, NDF, resistant to MLB and TLB.
Forage cowpea (*Vigna unguiculata*)		
MFC-09-3	Karnataka	Suitable for rainfed/irrigated, condition, forage yield 272.5 q/ha, resistance to rust, powdery mildew, and *Macrophomina* blight.
Chhattisgarh Chara Barbati 1 (RFC-2) (RCC-48)	West Bengal, Jharkhand, Bihar, Uttar Pradesh, Imphal, Assam, Odisha and Chhattisgarh	Suitable for rainfed and late conditions, grain yield 4.5–5.0 q/ha, maturity 140–150 days (seed to seed), crude protein 15.13%, IVDMD 58.9%, moderately resistant to mosaic and resistant to root-rot and less preferred by aphids.
Berseem *(Trifolium alexandrinum)*		
Bundel Berseem 5 (JHB-17-2)	Uttarakhand, Punjab, Haryana, Rajasthan, West Bengal, Jharkhand, Bihar, Eastern Uttar Pradesh and Odisha	Suitable for timely-sown, irrigated, conditions during *rabi*, multicut fodder, yield in high green-fodder 867.0 q/ha (NWZ), 411.0 q/ha (NEZ) and crude protein 19.0 q/ha (NWZ), 12.0 q/ha (NEZ); maturity 175 days from seedling to seed maturity, highly responsive to phosphorus fertilizer, moderately resistant to root-rot disease, leaf defoliators and resistant to *H. armigera.*
Bundel Berseem 6 (JHB-17-1)	Uttarakhand, Punjab, Haryana, Rajasthan, West Bengal, Jharkhand, Bihar, Eastern Uttar Pradesh and Odisha	Suitable for timely-sown, irrigated, during *rabi*, multicut fodder, yield in high green-fodder 835 q/ha (NWZ), 431 q/ha (NEZ) and crude protein 17 q/ha (NWZ), 11 q/ha (NEZ); maturity 180 days from seedling to seed maturity, highly responsive to phosphorus fertilizer, moderately resistant to leaf spot and leaf blight, leaf defoliators and resistant to *H. armigera.*
BL 45 (BM 12)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Rajasthan, Uttar Pradesh, Maharashtra, Madhya Pradesh and Chhattisgarh	Suitable for irrigated, timely-sown *rabi* season, multicut system, yield NW zone 821 q/ha (GFY), 114 q/ha (DMY), 21.2 q/ha (CPY); Hill zone 280q/ha (GFY), 48 q/ha (DMY), 9.4 q/ha (CPY); Central zone 612 q/ha (GFY), 97 q/ha (DMY), 15.6 q/ha (CPY), maturity (from seed to days to last cut) 257 days; (from seed to seed) 245–260 days, 17.1% protein in fodder (in dry basis), 63.5% *In vitro* dry-matter digestibility (IVDMD), highly responsive to phosphorus fertilizer, resistant to root-rot, moderately resistant to stem-rot, leaf spot and blight, and resistant to *H. armigera.*
Bundel Berseem 7 (JHB-18-1)	Punjab, Haryana, Rajasthan, Union Territory Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Maharashtra	Suitable for irrigated, timely-sown *rabi*, green-forage yield 825.0 q/ha (North-West zone), 630.0 q/ha (Central zone) and 300 q/ha (Hill zone), dry-matter yield 114 q/ha (North-West zone), 100 q/ha (Central zone) and 50 q/ha (Hill zone), maturity 170 days (seedling to seed maturity), moderately resistant to stem-root and resistant to root-rot disease, and *H. armigera.*
Bundel Berseem 8 (JHB-18-2)	Punjab, Haryana, Rajasthan, UT of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Maharashtra	Suitable for irrigated, timely-sown *rabi* conditions, green-forage yield 823 q/ha (Northwest zone), 598 q/ha (Central zone) and 297 q/ha (Hill zone); dry-matter yield 114 q/ha (North west zone), 97 q/ha (Central zone) and 51 q/ha (hill zone), maturity 185 days (seedling to seed), moderately resistant to stem root and resistant to root-rot disease, and *H. armigera.*
Napier (*Pennisetum* spp.)		
DHN-15	Karnataka	Suitable for irrigated, condition, green-fodder yield 2,000–2,500 q/ha, maturity perennial, and tolerant to medium moisture stress.
Others Crops		
Buckwheat (*Fagopyrum esculentum*)		
Him Phaphra	Himachal Pradesh, Uttarakhand and Jammu and Kashmir	Suitable for rainfed, *kharif* season, grain yield 5.9 q/ha, maturity 105 days, protein content 13.10%, and methionine content 1.32 g/100 g protein.

Variety	Area of adoption	Salient features
Quinoa (*Chenopodium quinoa*)		
Him Shakti	Punjab, Delhi, Uttar Pradesh, Rajasthan, Maharashtra, Chhattisgarh, Jharkhand, Odissa and Karnataka	Suitable for irrigated, *rabi* season in plains, grain yield 14.7 q/ha, maturity 113 days, protein content 15.56%, oil content 9.26%, and first quinoa variety of the country.
Asalio (*Lepidium sativum*)		
HLS 4 (Chandrasur)	Haryana, Punjab, Himachal Pradesh, Western Uttar Pradesh, Jammu and Kashmir	Suitable for irrigated,/rainfed and normal sown conditions which give high seed yield, seed yield 14–15 q/ha, maturity 116 days, oil yield 3.07 q/ha, oil content 20.61%, resistant to diseases and insect-pests, narrow, imparipinnate, and unipinnate leaves.
White clover (*Trifolium repens*)		
Him Palam White Clover 1 (PWC 25)	Himachal Pradesh, Jammu and Kashmir and Uttarakhand	Suitable for pastures, grassland, wastelands and orchards of hill zones, sub-temperate and temperate climate, fodder yield 350–450 q/ha (green herbage in 3–4 cuttings), maturity 180–200 days (seed to seed), green-fodder contains 19–20% crude protein, very nutritive for grazing animals, tolerant to cold and frost, moderately resistant to powdery mildew, and no major insect-pest has been observed.

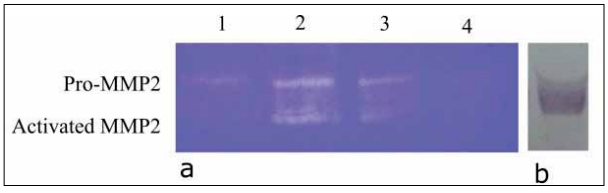
Mapping of QTLs for yield, nutritional quality and stress tolerance

Identification of QTLs for traits associated with drought tolerance: A novel QTL (Qlr.nhv-5D.2) on a 5D chromosome flanked by markers AX-94892575-AX-95124447 was IRC II Report 2021-22 11 identified for leaf rolling under moisture-stress condition in bread wheat. Two new candidate leaf rolling genes, viz. *TaZHD1* and *TaZHD10* belonging to homeodomain-leucine zipper (HD-Zip) class IV family proteins (gene) which are closest to orthologs of rice *OsZHD1* and *OsZHD10* were identified in the QTL region.

Markers for C1-Inhibitor (C1-I) locus that interferes with R1-nj expression: Two C1-I specific breeder-friendly markers (MGU-CI-InDel8 and MGU-C1- SNP1) covering (i) 8 bp InDel and (ii) A to G SNP were developed. MGU-CI-InDel8 and MGU-C1-SNP1 markers predicted presence of C1-I allele with 92.9% and 84.7% accuracy, respectively. However, when both markers were considered together, they provided 100% accuracy

GWAS for phosphorous uptake and utilization efficiency in mungbean: Mungbean (*Vigna radiata*) is an early maturing legume grown predominantly in Asia for its protein-rich seeds. The genetic dissection of PUpE (P uptake efficiency) and PUtE (P utilization efficiency) traits are essential for breeding mungbean varieties with a high P uptake and utilization efficiency. A genotyping-by-sequencing (GBS) based genome-wide association study (GWAS) approach using 120 genotypes was employed to dissect the complexity of PUpE and PUtE traits at the genetic level in mungbean. This has identified 116 SNPs in 61 protein-coding genes and of these, 16 have been found to enhance phosphorous uptake and utilization efficiency in mungbean. Identified six genes *(VRADI01G04370, VRADI05G20860, VRADI06G12490, VRADI08G20910, VRADI08G00070* and *VRADI09G09030*) with a high expression in root, shoot apical meristem and leaf, indicating their role in the regulation of P uptake and utilization efficiency in mungbean. The SNPs present in three genes have also been validated using a Sanger sequencing approach.

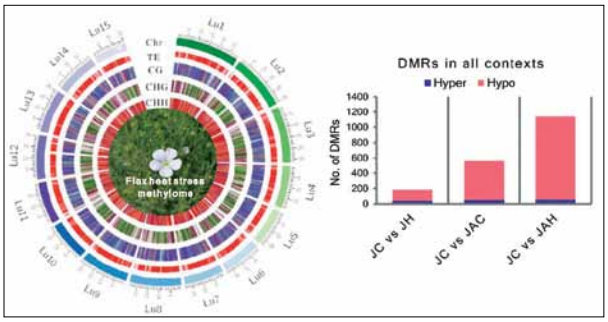
Jute leaf flavonoids inhibit human matrix metalloproteinase 2 (MMP 2) activity: Matrix metalloproteinases (MMPs), a group of endopeptidases involved in tumor cell metastasis, are widely used as biomarkers of carcinoma and its therapeutic targets. The potential of jute flavonoids as an anti-MMP-2 agent was investigated using gelatin zymography and immunoblotting. Flavonoid extract from *Capsularis olitorius* JRO 524 inhibited the breakdown of pro-MMP-2 into active MMP-2, thereby rendering it inactive. The extent of inhibition was at par with the positive control [epigallocatechin gallate (EGCG)] and higher than that of flavonoids from *C. capsularis* cv. JRC 212. The presence of flavonoid compounds like catechin, apigenin, quercetin, and genistein in jute that block MMP activity was confirmed. The high anti-MMP2 activity of jute flavonoids in vitro indicates the anti-tumorigenic potential of jute flavonoids.



Inhibition of MMP-2 activity by jute leaf flavonoids. (a) Gelatine zymogram of human MMP-2 treated with different flavonoid inhibitors (1: MMP-2+Tea epigallocatechin gallate, 2: MMP-2+distilled water, 3: MMP-2+*C. capsularis* flavonoids, 4: MMP-2+*C. olitorius* flavonoids). (b) Western blot of human MMP-2 with anti-human/mouse MMP-2 antibody.

Flax biotechnology for heat-stress adaptation: The adaptation of superior quality fibre flax cultivars to hot

and humid conditions is critical for the area expansion of flax in India. Plants use epigenetic methylation, also known as DNA methylation, to adapt to harsh environmental conditions. A bisulphite sequencing strategy was used to conduct a genome-wide survey of cytosine DNA methylation patterns in response to heat stress to investigate the adaptation of fibre flax cultivars to high temperature stress. This is the first report of a flax epigenomic study. The experiment was carried out on seedlings of JRF-2, a putatively heat tolerant fibre flax cultivar, which were either treated or not treated with a hypomethylating agent, 5-Azacytidine (5-AzaC). The samples were then compared between heat-stressed seedlings and control seedlings. Bisulphite sequencing in flax under heat stress conditions identified 85.1-90.5 million methylated DNA loci in CpG/CHG/CHH sequence contexts. From the analysis of differentially methylated regions, it was concluded that DNA hypomethylation is the primary response to heat stress in flax. A DNA hypomethylating agent, 5-Azacytidine, was found to be effective in modulating hypomethylations to stabilize heat stress-induced oxidative damage in flax fibre.

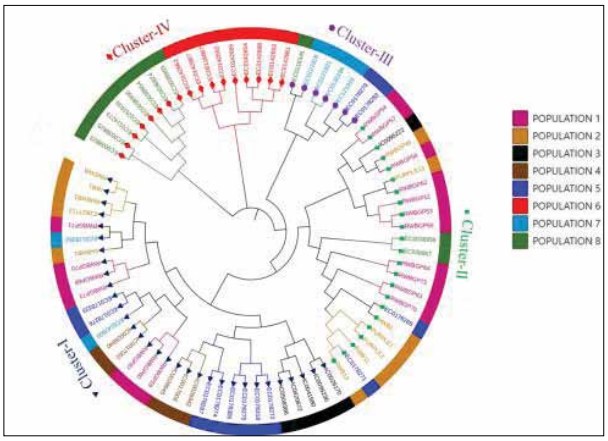


CIRCOS diagram showing mapped cytosine DNA methylation loci in terms of CpG, CHG, and CHH contexts in flax chromosomes. The bar diagram representing distribution of hyper and hypomethylated differentially methylated genomic loci under different treatment combinations. JC: flax-control; JH: flax-heat; JAC: flax-AzaC-control; and JAH: flax-AzaC-heat.

Molecular Breeding for the Development of Rice Varieties with Inbuilt Resistance/Tolerance to Drought, Low Soil P, and Blast

Seven hundred fifty plants selected based on *per se* performance from F_2 populations of rice segregating for *qDTY 2.2, qDTY 4.1* and *Pup1* were raised during *kharif* 2022 under direct seeded rainfed conditions for evaluation. Based on genotyping of 326 selected plants with the help of linked markers, plants possessing different combinations of QTLs were identified. The average performance for grain yield of the plants containing both the DTYs in homozygous conditions and *Pup1* was superior to plants either devoid or carrying one or two QTLs. For evaluation and selection, F_2 populations segregating for *Pi-54*, *Pi2*, *Pi9*, and *Pup1* were also raised during *kharif* 2022.

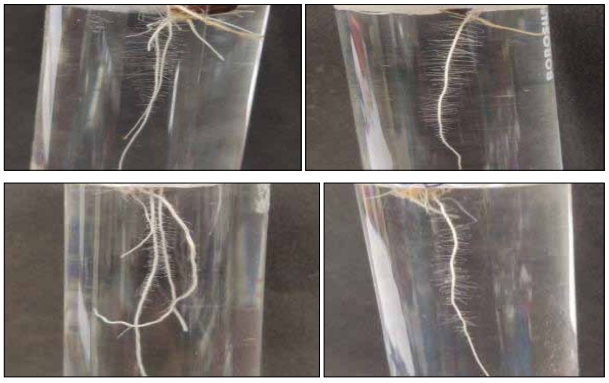
Development and characterization of EST-SSR markers in winged bean: Winged bean (*Psophocarpus tetragonolobus*) is a high-protein, high-oil orphan tropical legume. A set of genic-SSR markers for winged bean was developed from the publicly available RNAseq data sets. Fifty-eight thousand eight hundred eleven unigenes were assembled, and 4,107 perfect SSRs were identified. Primers were synthesized for randomly selected 166 SSRs (di-nucleotide and above) of which 78 amplified single band, and from among them 22 were polymorphic in a set of 79 germplasm accessions of winged bean from India, Thailand, Nigeria, Indonesia, Taiwan, the Philippines, and Papua New Guinea. These accessions wee grouped into eight hypothetical populations based on their geographic location. Sixty alleles were detected at the 22 polymorphic SSR loci, with a mean value of 2.73 per locus. The PIC values for the SSR loci ranged from 0.11 to 0.64 (mean 0.36). The analysis of molecular variance (AMOVA) indicated that within-population variation was significantly higher (85%) than between-population variation (15%). The pairwise Nm values between the populations ranged from 0.69–3.41, indicating the varying level of gene flow between them. The analysis of the population structure revealed two distinct groups among the eight populations with different levels of introgression. The groupings were further confirmed by allelic richness test between and among groups, fuzzy clustering and discriminate analysis. The NJ based clustering grouped the 79 germplasm accessions of the winged bean into four main clusters with significant clustering of geographically proximal accessions. The genic-SSR markers discovered in the study would speed up breeding for modern varieties and help develop effective conservation strategies for the species.



NJ tree showing the genetic relationships among the 79 germplasm accessions of winged bean grouped into eight hypothetical geographic populations.

Comparative study of zinc responsive genes in contrasting rice genotype under zinc-deficient condition: The adaptive changes during early exposure to zinc-deficit conditions have not been adequately studied in contrasting rice genotypes differing in their

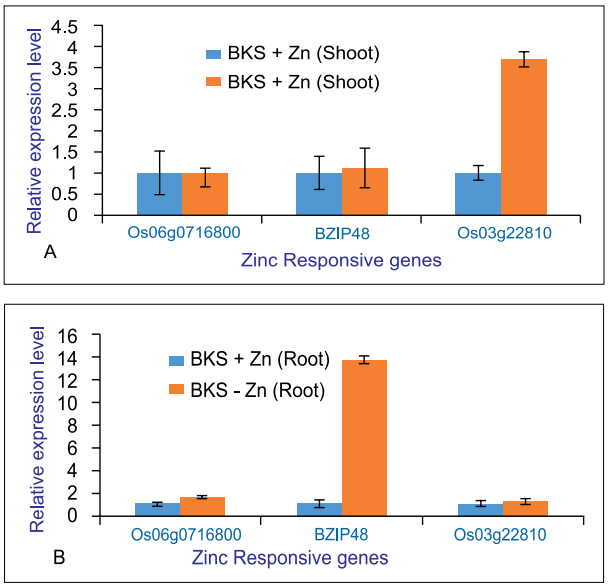
seed zinc content. Therefore, two contrasting rice genotypes, BKS 41 and Sadabahar, differing in their seed zinc-content (18 and 44 ppm respectively) were tested in hydroponics with two different doses of zinc (5 and 0.005 µM) and the effect of Zn deficiency was evaluated at morpho-physiological, biochemical and molecular levels. Some important morphological traits such as shoot length, crown root number, root traits (length, root hair zone and density) relative chlorophyll content and total dry weight were analyzed. Genotype BKS-41 (high seed zinc) showed higher shoot length, root length, longer root hair zone, high root hair density, higher relative chlorophyll content and dry weight as compared to Sadabahar (low seed zinc) under zinc deficit condition showing its physiological superiority over Sadabahar.



Effect of zinc deficiency on different root traits. BKS 41 (with higher seed Zn content) showed longer root and root hair zone with higher hair density.

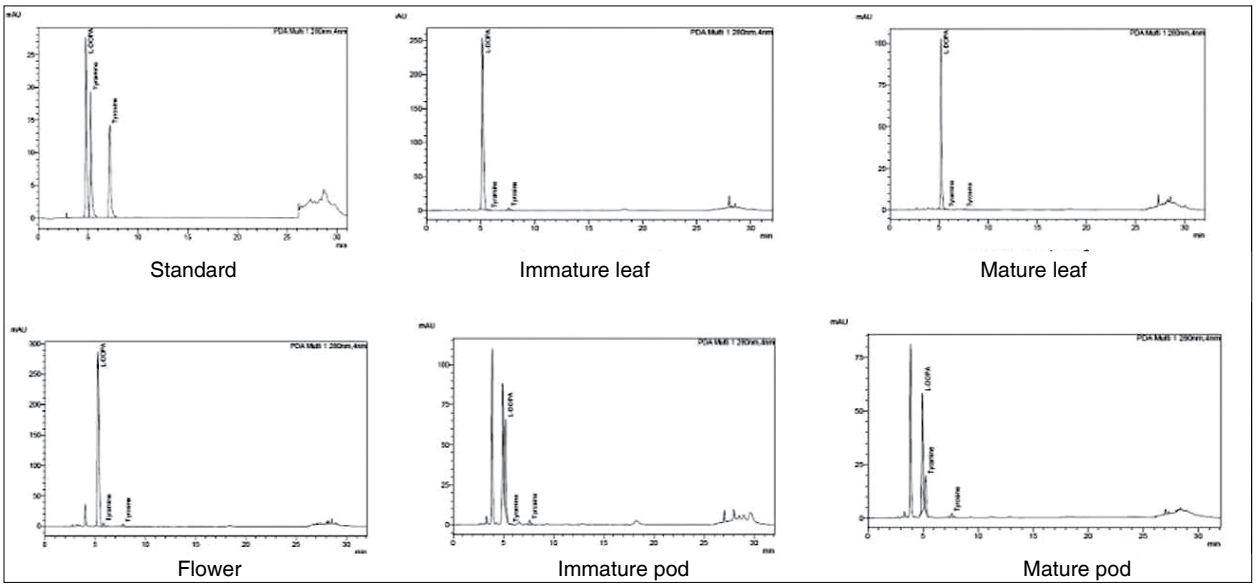
Antioxidant enzymes analysis showed that the activity of superoxide dismutase, ascorbate peroxidase and glutathione reductase were higher in BKS 41 compared to Sadabahar indicating better scavenging capacity in the high zinc genotype under zinc-deficient conditions. Transcription factors bZIP19 and bZIP23 act as central regulators of Zn deficiency response in *Arabidopsis.* Therefore, the ortholog genes *Os06t0601500-02* (bZIP 48) and *Os06g0716800* (bZIP 53), and a zinc deficiency responsive Cu/Zn SOD gene (*Os03g22810*) were selected and validated through qRT-PCR. The expression profiling of zinc-responsive gene *OsbZIP48*, OsbZIP53 and Os03g22810 (Cu/Zn SOD) showed that *OsbZIP48*, which plays significant role in zinc homoeostasis, was significantly upregulated in BKS-41 root. The gene *Os03g22810* (Cu/Zn SOD) showed significant upregulation in BKS-41 in shoot under zinc-deficient conditions. The contrasting yet differential gene expression of bZIP48 in root and shoot tissues in both genotypes pointed to the plausible role of this gene in tissue-specific Zn homeostasis under Zn deficit conditions. Analyzing the overall performance at the morpho-physiological level followed by higher activity of antioxidant enzymes and induction of gene *OsbZIP48* in root tissue in genotype BKS 41 under zinc deprivation suggested its better zinc use efficiency.

Molecular regulation of RFOs accumulation in peanut: Raffinose family oligosaccharides (RFOs), generally regarded as antinutrients, also play an important role in plant physiology. A study was conducted to identify regulatory genes associated with RFOs biosynthesis in peanut (*Arachis hypogaea*) and to study their spatiotemporal gene expression. RNA-seq was performed in immature seed stage (S1) and matured seed stage (S2) of three contrasting varieties: TG37A (high RFOs) and GG7 (low RFOs), from the Spanish group and Girnar 2 (high RFOs), from the Virginia group. The transcriptomic data were validated through qRT-PCR, which suggested the temporal and tissue-specific gene expression of different families of RFOs biosynthetic genes in the contrasting genotypes. Although profiling of RFOs sugars showed stachyose as the major component of RFOs (more than 90%), gene expression suggested the regulatory roles of Raffinose Synthase (RS) instead of Stachyose Synthase (StS) for the differential accumulation of RFOs. Among RS, significant differential and seed-specific expression of *AhRS*14 and *AhRS*6 indicated their regulatory role, while constitutive expression of *AhGolS*6 and *AhSS*7 at all seed stages suggested their important roles during seed maturity. Selective expression of homeologous genes also highlights their evolutionary significance during allopolyploidization. The identified genes can further be validated in a larger population and in other legumes to develop low RFOs varieties, thus improving the overall nutritional quality and solving the discomforts associated with their consumption.



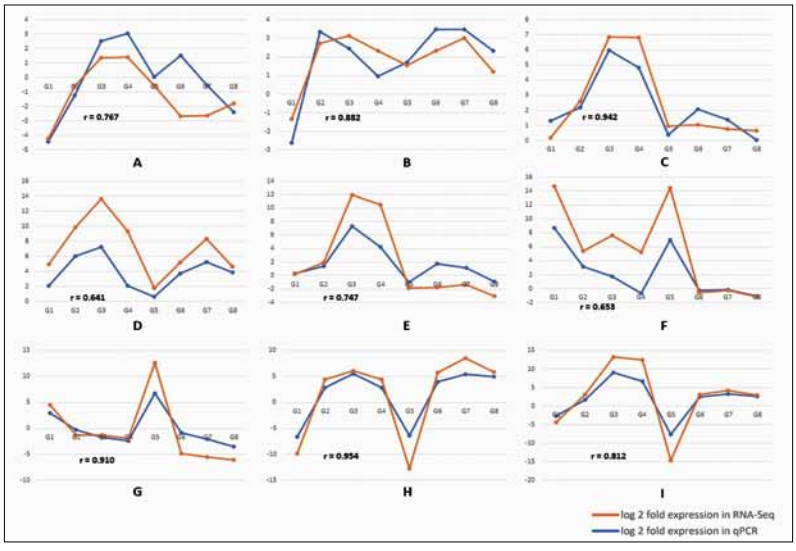
Relative expression levels of *Os06g0716800*, *OsbZIP48* and *Os03g22810* were compared in the shoot (A) and root (B) after 1 week of treatment under Zn sufficient (+Zn) and Zn deficient (-Zn) condition. Note: All expression level were normalized with respect to endogenous control Actin, OsActin and all three genes *Os06g0716800 (OsbZIP53), OsbZIP48* and *Os03g22810* were determined by $2^{-\Delta CT}$ method. Bars represent mean fold change in the transcript level of three biological replicates ±SE.

Exploring the potential of Faba bean as a natural source of L-Dopa: Faba bean (*Vicia faba*) is a good



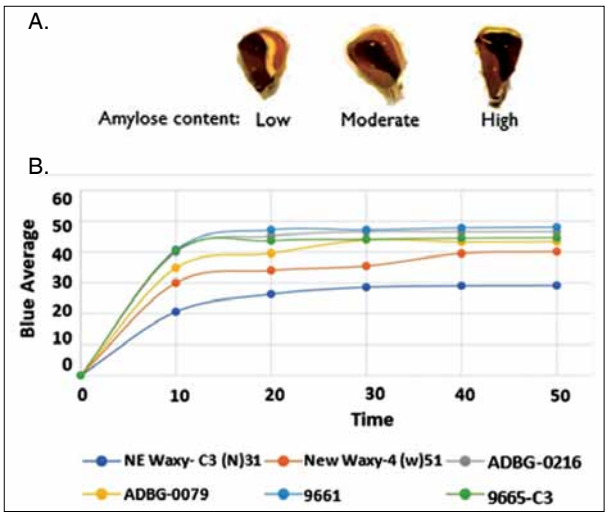
Comparison of L-Dopa content in various plant tissues of faba bean. Estimation by HPLC showed higher L-Dopa content in flowers.

source of protein, vitamins, and other bioactive compounds like L-3, 4-dihydroxyphenylalanine (L-Dopa). The different tissues of the crop have been reported to contain enough L-Dopa to be pharmacologically active on patients with Parkinson's disease. The amount of L-Dopa may vary considerably, depending on the species, climate zone, soil conditions, precipitation and other factors. In the present study, four released varieties of faba bean, i.e. Swarna Suraksha, Swarna Safal, Swarna Gaurav and Pusa Sumeet were grown under controlled polyhouse conditions and evaluated for L-Dopa content. From 60-day old plants, fresh tissues, viz. young leaves, fully grown leaves, flowers, tender pods, and mature pods were used for the study. Differential accumulation patterns and content of L-Dopa were observed in different tissues, which also varied among genotypes. The content of L-Dopa (on fresh weight basis) was found to be higher in flowers (2.13–4.42%) and young leaves (3.15–4.37%), followed by fully grown leaves (0.54–1.33%) and immature pod (0.51–1.27%). The least content was observed in matured pod tissues, i.e. 0.22 to 0.39%. Due to the presence of higher amount of L-Dopa, the immature leaf and flowers can be used as an alternative source.



qPCR validation of RNA-seq data, graphs showing the correlation of log 2 fold change of RFOs related genes (*G1: AhGolS4; G2: AhGolS6; G3: AhRS14; G4: AhRS4; G5: AhRS6; G6: AhRS8; G7: AhRS3;* and *G8: AhSS7*) to that of RNA-seq data. The graph also depicts the differential gene expression in contrasting genotypes at immature seed stage (S1) and matured seed stage (S2) (A: TG37A (S2 vs S1); B: GG7 (S2 vs S1); C: Girnar2 (S2 vs S1); D: TG37A vs GG7 (S1); E: TG37A vs GG7 (S2); F: TG37A vs Girnar2 (S1); G: TG37A vs Girnar2 (S2); H: Girnar2 vs GG7 (S1) and I: Girnar2 vs GG7 (S2).

Development of a rapid single kernel screening method for preliminary estimation of amylose in maize: The development of low glycaemic index maize varieties requires screening of a large number of inbreds. Conventional methods of amylose estimation are time consuming. A simple and rapid screening method has been designed for amylose estimation in maize kernels, which is based on the principle of amylose-iodine complex formation. This method involves cutting of maize kernel longitudinally to expose the endosperm, followed by treatment with optimized potassium iodide:iodine (2:1) solution on the cut end and recording the time involved for maximum colouration. It was observed that time taken for iodine to reach its maximum colouration had an inverse relation to the amylose content in maize kernel. The method was validated in a large set of maize samples with varied amylose content and automation was done with the use of AlphaView SA

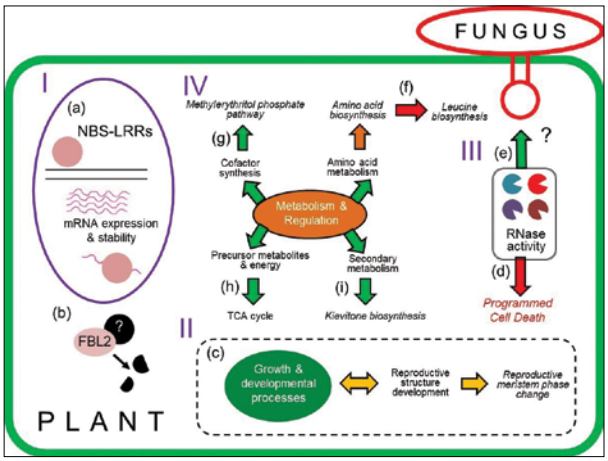


Kernel colour development after 10 seconds in KI:I reagent

software. The proposed method is a rapid and simple for screening of maize kernels with varied amylose amounts, and gets completed in 1 min, making it suitable for large-scale screening of maize germplasm including mutants and wild types.

Meta-QTL analysis for fungal disease resistance in maize and identification of the inherent mechanistic pathways: An extensive literature search was conducted to find published QTL mapping studies for 19 fungal diseases of maize. The diseases were Southern corn leaf blight (SLB), Northern corn leaf blight (NCLB), Banded leaf and sheath blight (BLSB), Anthracnose leaf blight (ALB), Grey leaf spot (GLS), Curvularia leaf spot (CLS), Phaeosphaeria leaf spot (PLS), Head smut (HS), Common smut (CS), Gibberella ear rot (GER), Aspergillus ear rot (AER), Fusarium seedling rot (FSR), Fusarium ear rot (FER), Maize stalk rot (MSR), Sorghum downy mildew (SDM), Java downy mildew (JDM), Rajasthan downy mildew (RDM), Common rust (CR), Southern rust (SR). A total of 82 QTL mapping experiments from 63 studies having required information, viz. trait, mapping population, QTL, its position, LOD values, CI, group, phenotypic variance and genetic map were used for the study. The MQTL analysis revealed the projection of 33.59 % (128) QTLs associated with resistance against 12 fungal diseases (SLB, NCLB, BLSB, GLS, HS, FSR, FER, GER, AER, PLS, CS, SDM) across the maize genome. A total of 38 MQTL regions were identified on the 9 chromosomes of maize (Ch1 to Ch9). The results revealed that on Ch 1, 2, 3, 4, 6, and 8, there were 5 MQTLs each; on Ch 5, there were 4 MQTLs; and on Ch 7 and 9, there were 2 MQTLs each. In comparison to the initial CI of individual QTLs from particular research located in that MQTL region, the confidence interval (CI) value of each MQTL was dramatically reduced. Therefore, in the present research work, five MQTL regions (2_4, 1_4, 3_4, 3_2 and 5_4) were linked with multiple diseases. Total of 1910 candidate genes were identified for all the MQTL regions, with protein kinase gene families, TFs, pathogenesis-related, and disease-responsive proteins directly or indirectly associated with FDR.

The study also attempted to unravel the underlying mechanism for FDR resistance by analyzing the constitutive gene network, which will be a useful resource to understand the molecular mechanism of defense-response of a particular disease and multiple FDR in maize. In terms of pathways, cofactor synthesis, secondary metabolism and amino acid metabolism and tricarboxylic acid cycle were found to be involved. The methylerythritol phosphate pathway, kievitone and leucine biosynthesis were found to be activated for the above mentioned genes. Rest of the genes either mapped to unknown pathways or constituted the structural components like the cytoskeleton. The linked markers to MQTL and putative candidate genes underlying identified MQTL can be further validated in the germplasm through marker screening and expression studies.

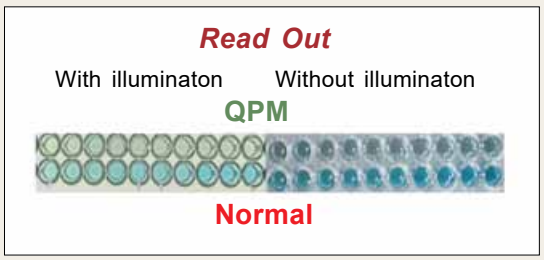


Schematic representation of the role of maize constitutive gene network in fungal resistance. (A) Nuclear expression is initiated majorly by NBS-LRRs. (B) FBL2, structurally similar to FBL41, was found to be highly expressed in most of the plant developmental stages. II. (C) Amongst the growth & developmental processes, reproductive structure development is found as a major phenotypic change. III. RNases may play a dual part in inducing programmed cell death to activate systemic plant defenses (D) or in reducing the fungal mRNA pool (E). IV. Metabolic reprogramming leads to both positive and negative regulation of antifungal resistance. (F) Leucine can be potentially utilized by fungus for plant infection. (G) Cofactor synthesis, (H) energy metabolism and (I) kievitone biosynthesis are important in modulating plant response to fungal challenges.

Genome editing in chickpea for early flowering and seed size: In effort to develop an early flowering chickpea, the early flowering 1 gene (*Efl1*) was mined for identification of SNPs and Indels in its coding and upstream region. Dual guide RNA (targeting exon1 and exon 2 of *Efl1* gene) have been developed using the InFusion cloning technology and the protocol for induction of adventitious roots from embryonic axis infected with *Agrobacterium rhizogenes* (A4) strain has been standardized. Also, targeting the seed size of chickpea, 12 constructs having different sgRNAs

Filing of Patent Related to Protein Quality Assessment in Maize Grains

Filed application for an Indian patent (Application No. 202211015547) on rapid differentiation of normal maize from Quality Protein Maize. The developed method requires 5 min for differentiating normal maize from QPM, when a milled sample is provided. This is expected to enable premium remuneration to QPM growers, given the utility of QPM in animal and human health. The colour developed can be read in spectrophotometer of ELISA reader for differentiation of samples, based on protein quality.



Colour-based differentiation of maize samples on the basis of protein quality

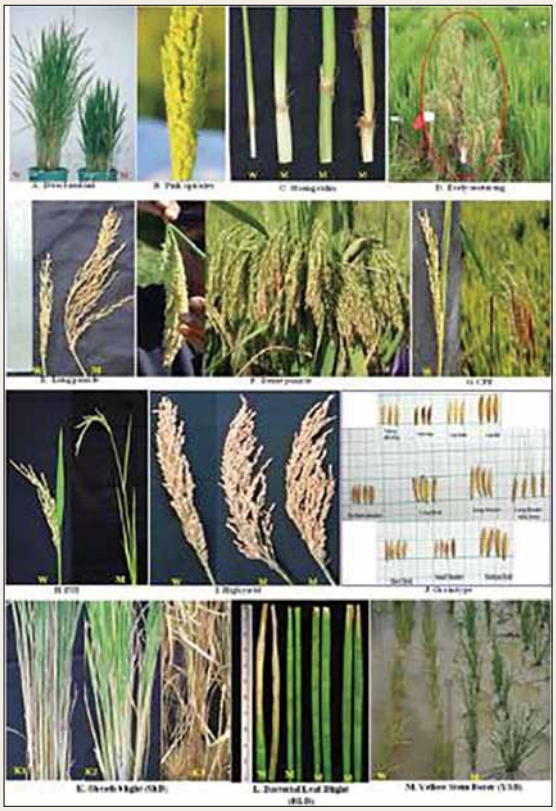
targeting TIFY and CCT_2 domain were developed which were used for Agrobacterium mediated genetic transformation of chickpea. Of these, transformed plants from 8 constructs could be established in PBSL1 facility. These edited chickpea lines display increase in leaf size, stem length and seed weight as compared to their normal control type (s).

Identification of genes for ODAP synthesis for genome editing in grasspea: Full-length gene sequence of grasspea oxalyl-CoA synthetase and ODAP synthase, enzymes functional in OAP synthesis in grasspea, have been identified and submitted to Genbank with accession No. MH469748 and MZ127288, respectively. sgRNAs around the conserved region or N-terminal, half of these genes have been designed, synthesized, and cloned into CRISPR/Cas vector (pKSE401) using Golden Gate cloning and are being mobilized in *Agrobacterium rhizogenes* for quick assessment of the effectiveness of gRNAs for genome editing in grasspea. *Agrobacterium rhizogenes* mediated transformation for hairy root induction in grasspea has been attempted using 5 days old seedlings of grasspea (cv. Mahateora). Preliminary results showed the hairy root induction efficiency in grasspea was 21.5% using cotyledon explant with attached short hypocotyl.

Hairy root induction in grasspea using cotyledon explants with attached short hypocotyl

Two QTLs mapped for *Fusarium* wilt resistance in pigeonpea: The Bulked Segregant Analysis-Sequencing (BSA-seq) approach was utilized to map genomic region responsible for *Fusarium* wilt (FW) resistance in pigeonpea with F_2 mapping population derived from Bahar (FW susceptible) and Maruti (FW resistant) genotypes. The $F_{2:3}$ segregants were screened for *Fusarium* wilt incidence in FW sick plot at ICAR-IIPR main farm, Kanpur. The extreme phenotypic segregants for the trait were identified, and pooled to constitute resistant and susceptible bulk. These along with one of its parent, viz. Maruti were subjected to whole genome resequencing and its analysis revealed that 2 QTLs/genomic region on chromosome 2 and 8 were responsible for *Fusarium* wilt resistance. Further fine mapping of this genomic region will be done using RIL population derived from Bahar and Maruti.

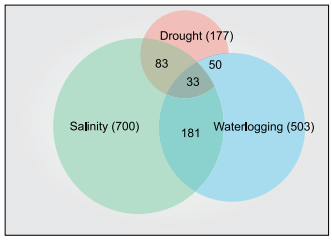
CRISPR/Cas based multiplex genome editing of indica rice cultivar for yield improvement: CRISPR/Cas technology was utilized to edit the cytokinin oxidase (*OsCKX2)* gene of rice controlling the grain number in order to increase the yield of Samba Mahsuri. Guide RNAs for two different exons of *OsCKX2* were designed and a CRISPR/Cas construct was developed to produce guide RNAs and Cas protein. The genome-editing



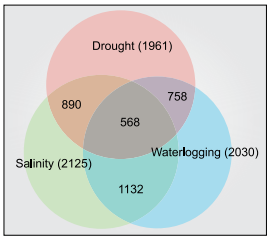
The genome-edited T0 lines showed 200 to 496 grains/panicle in comparison to ~150 grains/panicle in wild-type or non-edited Samba Mahsuri plants under glasshouse conditions. Further, phenotypic evaluation of selected T1 lines showed desired characters like strong culm and early maturity contributed by new allele of *OsCKX2*.

construct was stably expressed in Samba Mahsuri by using *Agrobacterium*-mediated genetic transformation. 40 independent T0 lines were obtained having a range of deletions, insertions, and substitutions (1bp to 77bp) at desired nucleotide sequences. The gRNAs showed 100% editing efficiency with ~95% biallelic mutations in T0 generation.

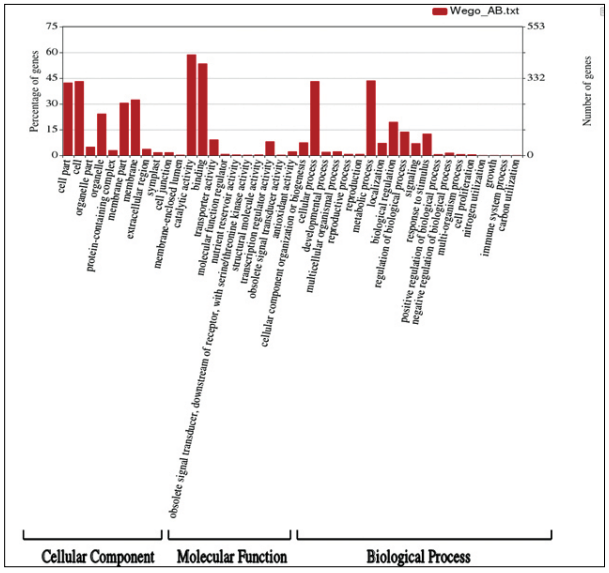
Mutation resource of Samba Mahsuri, BPT 5204: To create novel variants for morphological, physiological, and biotic stress tolerance traits, induced mutations were created using Ethyl Methane Sulphonate (EMS) in the background of Samba Mahsuri (BPT 5204), a popular and mega rice variety of India. Whole genome re-sequencing revealed substantial variation in comparison to Samba Mahsuri. The mutant lines showing enhanced tolerance to important biotic stresses (YSB, ShB and BLB) as well as several economically important traits are unique genetic resources which can be utilized for the identification of novel genes/ alleles for different traits. The lines which have better agronomic features can be used as pre-breeding lines. The entire mutant population is maintained as a national resource for genetic improvement of the rice crop (https://journals.plos.org/plosonearticle?id=10.1371/journal.pone.0258816).

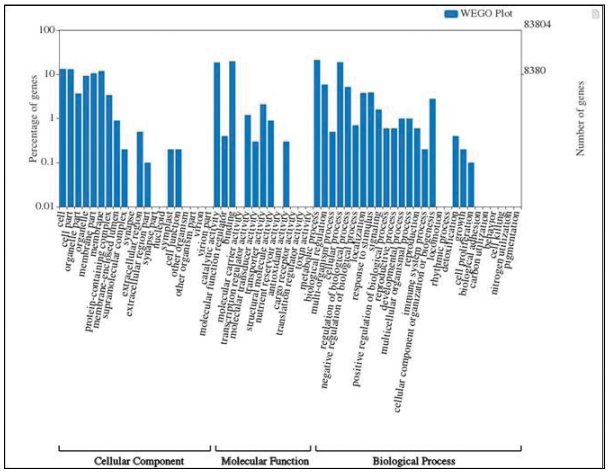


Up-regulated DEGs in Drought, Salinity and waterlogged sugarcane



Down-regulated DEGS in Drought, Salinity and Waterlogging



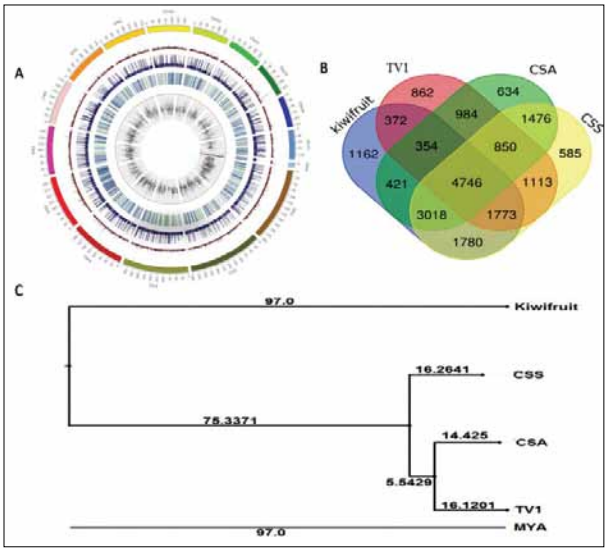


Detection of multiple abiotic stress responsive genes using transcriptomics in sugarcane: Among multiple abiotic stresses, drought caused maximum reduction in growth parameters and impacted the physiological parameters adversely while waterlogging led to maximum increase in catalase and peroxidase activities. Transcriptomic analysis database revealed 94,037, 94,226, 93,530 and 94,005 transcripts under control, drought, salinity and waterlogging treatments, respectively. Transcriptomic analysis was conducted using total RNA as starting material from sugarcane leaf samples of CoS 767 at the end of stress. Database summary revealed that 66,595 transcripts were annotated by Refseq database, 21,216 transcripts were annotated by Uniprot and 32,805 transcripts were annotated by PFAM database. Results depicted a total number of 94,037, 94,226, 93,530 and 94,005 transcripts under control, drought, salinity and waterlogging treatments, respectively. Differential expression analysis revealed 177, 690 and 500 significantly up-regulated transcripts under drought salinity and waterlogging conditions. Whereas, 1,961, 2,074 and 2,008 genes were found significantly down-regulated under drought salinity and waterlogging treatments, respectively.

Waterlogging responsive genes using transcriptomics in sugarcane: Four genotypes under waterlogging indicated changes in photosynthetic pigments, chlorophyll a and b, total Chl, carotenoids, Chl a/b, total Chl /CAR and SPAD index. Twenty four genotypes under waterlogging showed wide variation in Brix°, Sucrose% juice and juice purity. Under water-logging conditions, 447,196 transcripts were identified with an average length of 509 bp (N50=621) for the de novo assembly of 29,6518 unigenes with an average length of 529 bp (N50=664). The construction of cellulase cocktail enabled efficient hydrolysis pre-treated SCT. The total number of genes with differential expression were 69,365, 62,339, 70,352, 63,609 in control vs waterlogging (CoLk 94,184), CoLk 94,184 vs CoJ 64 (control), CoLk 94,184 vs CoJ 64 (waterlogging) and control vs waterlogging (CoJ 64), respectively.

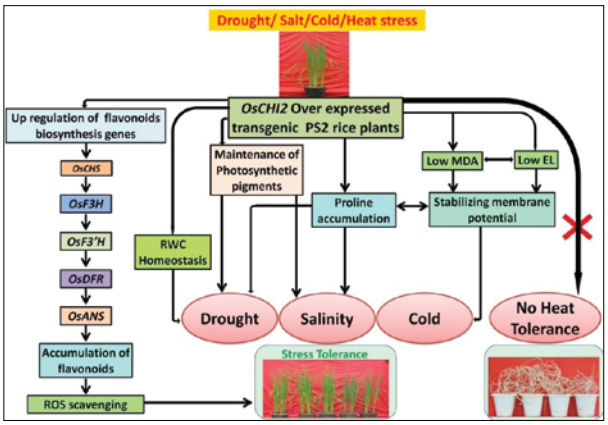
Chromosome level reference assembly of Indian tea genome: The genome size of an Indian tea (*Camellia assamica* var. Masters cv. TV1) was determined as 3.0 Gb using a FACS cell sorting facility. A chromosome-level reference genome assembly (2.93 Gb; 97.66% Coverage) was generated anchoring 99.40% of super-scaffold level assembly into 15 clusters or pseudomolecules by Hi-C

data with the size of clusters ranging from 303.18 Mb to 119.95 Mb. Repetitive or transposable elements in this TV1 genome accounted for a total of 2.07 Gb covering 70.61% of the assembled genome. The orthologous genes were predicted by Ortho MCL between TV1, *Camellia sinensis* var. *assamica* (CSA), *Camellia sinensis* var. *sinensis* (CSS), and Kiwi fruit. Further, the single-copy gene-based genome evolution has confirmed that divergence of TV1 occurred approximately 2 and 5.5 MYA from CSA and CSS, respectively. Whole-genome duplication (WGD) study has revealed the independent origin of TV1 when compared with Kiwi fruit, CSS, and CSA. A total of 30,039 high-confidence protein-coding genes were predicted in the genome.



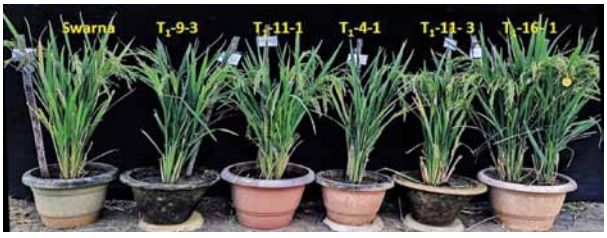
Indian Tea Genome Study. (A) Chromosome-wise distribution of genes, SSRs, ncRNAs and InDels (compared to CSS genome), (B) Venn diagram showing orthologs and paralogs between TV1, CSS, CSA, and Kiwi fruit, (C) Single-copy genes based tree considering the evolution time between tea and KIWI fruit as 73-97 MYA (million years ago) (http://www.timetree.org/).

Functional characterization of abiotic stress responsive genes from rice: A novel abiotic stress responsive gene *LOC_Os06g10210* (*OsCHI2*) which showed upregulation in response to drought stress was identified from the available global expression data. *OsCHI2* was isolated from a drought tolerant rice cv. Nagina 22 (N22) and transformed into a drought stress sensitive rice cv. Pusa Sugandh 2 (PS2) to express under the control of stress inducible *AtRd29A* promoter. Stable chromosomal integration of transgene was confirmed in the transgenic plants through molecular analysis. The expression level of the transgene in different transgenic lines was higher than wild type plants under abiotic stress condition. Physio-biochemical studies revealed that the transgenic rice plants upheld higher relative water content, more photosynthetic pigments and proline with lower relative electrolyte leakage and less malondialdehyde content as compared to wild type PS2 plants under drought, cold and salinity stresses. *OsCHI2* transgenic lines had enhanced transcript abundance of structural genes of flavonoids biosynthesis pathway leading to higher production of flavonoids under abiotic stresses in the OsCHI2 transgenic plants. Subsequently, in the non-transformed N 22 and PS 2 plants, the transcript abundance of the flavonoid genes was studied under control and moisture deficit stress conditions which clearly demonstrated the significantly higher transcript abundance of the six flavonoid biosynthesis genes in N 22 compared to PS 2 genes under moisture deficit stress. A linear pattern in the transcript abundance was also seen from the early to late pathway genes in descending order in N 22.



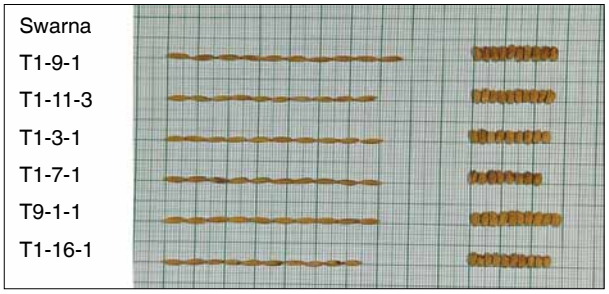
Regulatory network model of the *OsCHI2* gene involved in drought, salt and cold stresses responses. Over expression of *OsCHI2* transgenic PS2 rice plants up-regulate the genes involved in the flavonoid biosynthesis pathway, which result in significant physiological and biochemical changes, including accumulation of proline and flavonoids, less reduction of relative water content (RWC), photosynthetic pigments and lower MDA content and electrolyte leakage which lead to the improved drought, salt and cold tolerance.

Editing of miR156 site in *Ideal Plant Architecture 1* (*IPA1*) gene in rice mega variety, Swarna: The *Ideal plant architecture 1* (*IPA1*) gene is found to be responsible for increased spikelet number and panicle length in rice (*Oryza sativa*) making it a suitable target for the development of high-yielding rice varieties through genome editing. A *miR156* target site in the *IPA1* gene functions as negative regulator of yield related traits. Therefore, gRNA primers targeting *miR156* binding site in *IPA1* gene were designed and used for the development of *IPA1-Cas9* construct through golden gate assay. Using *Agrobacterium* transformation, *IPA1-Cas9* construct was transferred to the calli of popular *indica* rice variety Swarna.



Plant architecture of IPA1 edited lines in Swarna.

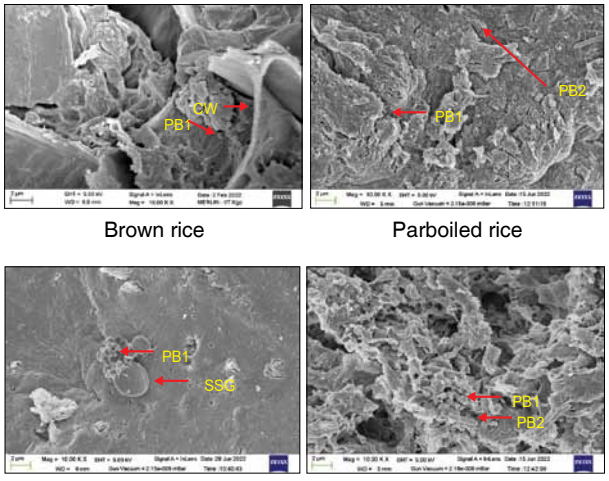
As of the many other traits, panicle architecture in edited lines was significantly improved. This includes improved panicle length and number of panicle branches. The mean number of panicle branches was ~26% higher than the parent variety Swarna. Similarly, spikelet number per panicle was higher by 21.3% over the parent variety. Among the edited lines, T1-9-3 showed the highest increase of all (Panicle branches: 15.44 nos.; No. of spikelets: 272.66 nos.). This resulted in ~23% increase in the single plant yield.



Grain type of Swarna and IPA1 edited lines.

Grain traits particularly grain length and width was found to be slightly different in the edited lines as compared to the parent variety Swarna. Especially, grain length in edited lines was smaller than the parent variety, Swarna.

Identification of the presence of Protein Body 1 and 2 in high protein rice CR Dhan 310: Protein molecules accumulate within two types of protein bodies (PB). PB-2 present in endosperm is more digestible in humans than PB-1 and therefore is nutritionally more important. PB-1 contains mostly prolamins, which are nutritionally inferior, and PB-2 contains mostly glutelins, nutritionally superior. The Scanning electron microscopy (SEM) of the endosperm of the rice variety CR Dhan 310 revealed the physical existence of protein along with starch granules. It was observed that parboiled polished



Brown rice | Parboiled rice

Parboiled polished cooked | Parboiled polished fermented

Scanning electron microscopy of protein body in high protein rice CR Dhan 310 under different post-harvest processing of grain (PB1: Protein Body 1; PB2: Protein body 2; SSG: Spherical Starch Granules).

Identification of High Resistant Starch Rice

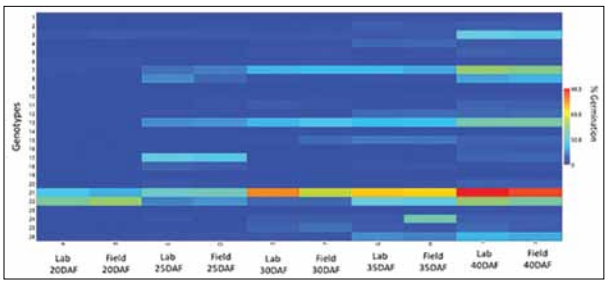
Starch is one of the primary nutrient and a key factor for determining rice grain quality. Based on its digestive properties, starch can be categorized into three groups: rapidly digestible starch, slowly digestible starch, and resistant starch. Resistant starch is not digested in the upper gastrointestinal tract and thus reaches the colon where it is fermented by microbiota to release acetate and propionate (short-chain fatty acids) which affect glucose and cholesterol metabolism in human. Resistant starch plays a crucial role in the reduction of postprandial blood glucose response which ultimately lowers the risk of obesity, insulin sensitivity thereby help combat type-II diabetes and chronic kidney diseases. Higher content of resistant starch facilitates s lower digestion and ultimately blood sugar level is suppressed. Therefore, identification of high resistant starch rice could be a key player for dietary intervention to reduce starch digestibility and Glycemic index. In this context, 100 rice lines were estimated for resistant starch variation, variation was observed ranging from 0.28% to 2.94%. Among them Gayatri was found to have the highest resistant starch content of 2.94% over the years (2019 to 2022). Thus, Gayatri is expected to be useful for diabetics and the health-conscious people.

cooked rice contains more PB-1 than others whereas in brown rice, parboiled rice and parboiled fermented rice, the PB-1 and PB-2 are present in scattered manner. It was also seen that the starch granules become spherical in shape after cooking due to the effect of reorientation of starch chains, gelatinization and retrogradation. The innermost endosperm layer was compact without intracellular voids. The endosperm layer was highly organized by polyhedral or spherical starch granule (SG) and ellipsoidal/spherical protein bodies (PB). Starch granules tightly clustered into compound starch granule. These SG were surrounded by protein body. But in case of the rice variety Naveen, the protein bodies were present less frequently than CR Dhan 310, however the starch granules are present as polyhedral shaped.

Standardization of effective screening protocol for vivipary/pre-harvest sprouting in rice genotypes: The main objective of the study was to standardize an efficient evaluation method for identifying genotypic differences in viviparity. For standardization, two screening protocols i) field conditions and ii) laboratory

(a) (b) (c)

a) Labelling of panicles of each genotype according to flowering date in the field; (b) Field protocol (Lodging treatment: field protocol); (c) Laboratory protocol.



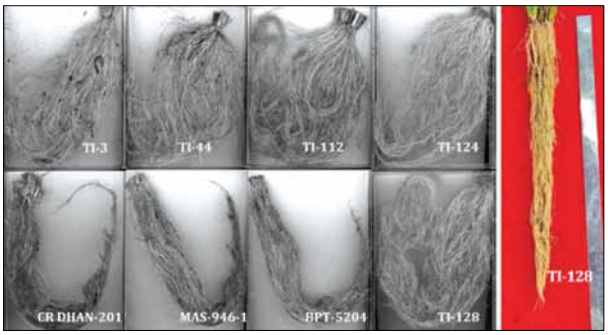
Matrix plot showing the similarity in viviparous germination between the field and lab protocols tested for evaluating 26 diverse genotypes for vivipary.

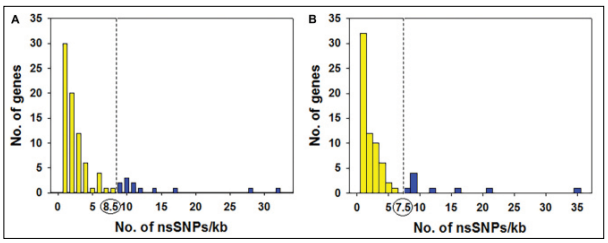
conditions were tested with 26 diverse rice genotypes. To induce viviparity at exact time after flowering, panicles of each variety were tagged according to the flowering date.

The viviparous germination percentage observed in field and lab protocols at 20, 25, 30, 35, 40 days after flowering was almost similar. Almost all the viviparous genotypes showed viviparity within 6 days after incubation both in the field and laboratory. A wide variability was observed in viviparous germination at different days after flowering in different rice genotypes. The results from field and laboratory showed almost similar viviparity. Laboratory protocol compared to field protocol is very convenient especially when screening large number of genotypes, because field protocol requires inducement of lodging, besides maintaining water level in the field so that panicles are always immersed in water for evaluating vivipary and daily counting of viviparous grains in the paddy field is also difficult. Hence to screen large number of genotypes for vivipary, laboratory method can be an efficient method considering the correlation with field observation data, outstanding genotypic difference and convenience of testing.

Mutants identified: Mutants of BPT 5204 having robust root system architecture, early seedling vigour index, and higher yield under limiting water conditions have been identified viz., TI 128, TI 124, TI 112, TI 3, TI 87 and TI 17. The lines are suitable for the dry direct seeded method of establishment with an aerobic system of cultivation management practice.

The genomes of an elite rice restorer line KMR3 (salinity-sensitive) and its salinity tolerant introgression line IL50-13, a popular variety of coastal West Bengal, India, were sequenced. Genes showing polymorphism



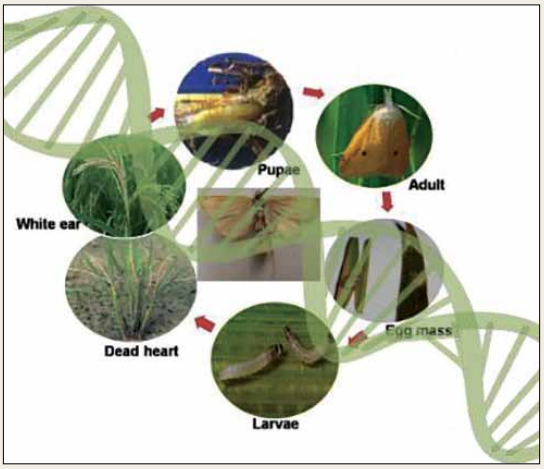


Degree distribution and skewness of the non-synonymous SNPs in KMR3 (A) and IL50-13 (B).

between the two genomes were considered as sequence-based new candidates derived from *Oryza rufipogon* for conferring high yield and salinity tolerance in IL50-13 for further functional studies.

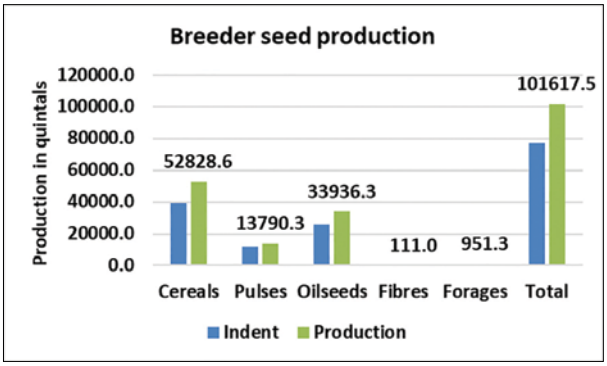
Draft Genome of Yellow Stem-borer *Scirpophaga incertulas* (Lepidoptera: Crambidae)

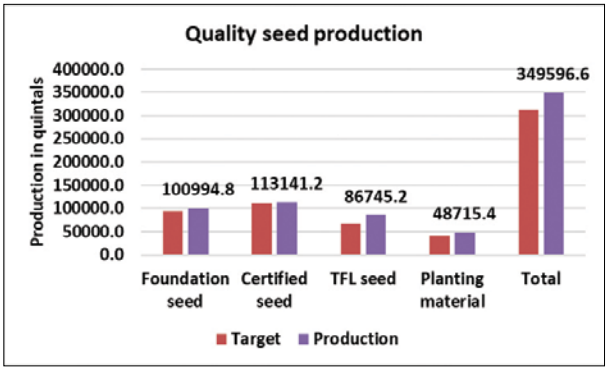
A draft genome of an agriculturally important pest with 46,057 genes and estimated size of 308 Mb has been generated. It provides molecular insights into its biology, development and specificity towards rice for infestation (https://www.mdpi.com/2075-4450/12/6/563).



Seed Production

Breeder seed production: During 2021-22, total breeder seed production in field crops was 1,01,617.5 q against the indent of 77,260.1 q. The major share in total breeder seed production belongs to cereal crops, i.e. 52,828.6 q against indent of 39,071.6 q. Under pulse crops a total of





13,790.3 q breeder seed was produced against the indent of 11,700.6 q. In oilseeds, total breeder seed production was 33,936.3 q against the indent of 25,817.0 q. Breeder seed produced in case of fiber crops was 111.0 q against the indent of 54.0 q and in forage crops, 951.3 q was produced against the indent of 616.9 q.

Quality seed production: During the year 2021-22, total production of quality seed including all classes was 3,49,596.6 q against the target of 3,12,584.7 q. Production comprises 1,00,994.8 q of foundation seed, 113,141.2 q of certified seeds, 86,745.2 q of truthfully labelled seed and 48,715.4 q of planting material of field crops. In addition, 234.5 lakh planting material and 5.4 lakh tissue culture plantlets were produced against the targets of 174.3 and 4.7 lakh, respectively.

Horticulture

A total of 122 varieties of horticultural crops comprising of fruits (15), plantation crops (1), vegetable crops (97), potato and tropical tuber crops (2) and spices (7) were notified by the Central Sub-Committee on Crop Standards for Cultivation under different agroclimatic conditions of India.

Following improved varieties of horticultural crops were identified for multilocation trial and recommendation for notification at National level.

Fruit Crops

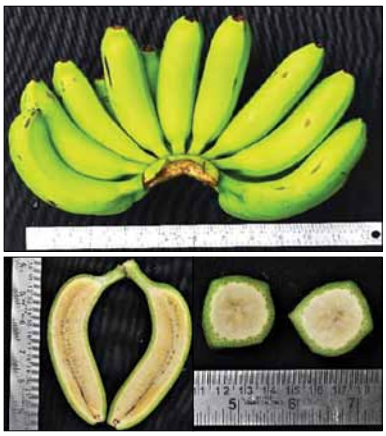
Bael: CISH B-3 is a mid-season maturing, seedling selection with thin shell, nearly thorn less, pulp is dark yellow with pleasant flavour and less mucilage content. Fruit weight is 1.15 kg with 65.64 kg fruit yield per tree (5-year old). Fruits have 38.04°B TSS, 0.44% acidity, 17.49% total sugars and 86.19% pulp.

Narendera Bael 11 (NB-11) ia an early maturing variety suitable for processing. Fruits have whitish yellow pulp with 33.98 °Brix TSS and ascorbic acid (35.15 mg/100 g of pulp). Fruit weight is 1.87 kg with 99.6 kg/tree productivity.

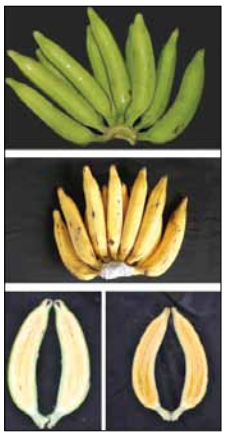
Banana: Popoulu (AAB, Plantain) is a high yielding (57.06 t/ha) and dual purpose (dessert & as chips making) with 32.5 % chips recovery and tolerant to pseudostem weevil, *Eumusae* leaf spot and identified for cultivation in Karnataka, Odisha, Tamil Nadu, Asom, Kerala, Andhra Pradesh, and West Bengal.

Kaveri Vaamana (TBM -9) is a dwarf mutant developed by irradiating the shoot tips of cultivar Grand Nain. The plant height is 150-160 cm with bunch bearing 8-10 hands weighing 18–25 kg. This dwarf variety doesn't require propping/staking which reduces the cultivation cost by 10-15%.

Kaveri Kanchan (NCR 17) is a stable, high yielding dessert banana hybrid (Nendran x Rose). This hybrid contains higher Pro-vitamin A (10 to 40 fold) than popular dessert banana cultivars like Red Banana, Grand Nain and Rasthali. It is highly resistant to Fusarium wilt pathogen (*Fusarium oxysporum* f sp. cubense Race 1) and yielding 20% higher than its parent (cv. Nendran). The fruits have superior, sweet taste (a blend of the Grand Naine taste and Nendran flavour) with higher consumer acceptability.



Fruits of Kaveri Vaamana (TBM-9)



Fruits of Kaveri Kanchan (NCR 17)

Custard apple: Thar Amrit has 320.12 g fruit weight with 24 kg/plant productivity. Fruits have high pulp content (63.58%). The fruit pulp has TSS 29.12°B and rich (/100 g pulp) in ascorbic acid (45-50 mg), iron (1.7 mg), phosphorous (26 mg), potassium (285.55 mg) and calcium (18.2 1mg) content.

Plantation Crops

Oilpalm: An advanced hybrid NRCOP 9 recorded significantly higher (173.25 kg/palm) bunch weight and 24.78t /ha fresh fruit bunch yield.

Coconut: Kalpa Vajra is a progeny of cross between varaible high yielding and root (wilt) disease-free West Coast Tall (WCT) palm genotypes, recorded less root (wilt) disease incidence and recommended for cultivation in root (wilt) disease prevalent tract.

Cashewnut: Nethra Jumbo 1 hybrid (NRCC Sel-2 and Bhedasi) has been identified for extra bold (12g) nut precocity, cluster bearing, higher yield (8 to 12 kg/tree), with more than 29% shelling and 3.4 g kernel weight which fits in to kernel grade of W130. It also saves the labour on harvesting, uniformity in nut size facilitates grading and ensures nearly 10% more price to farmers due to bold nuts.

Vegetables

Brinjal: IVBHL 22 is dark purple and long fruited variety identified for zone-VII (Madhya Pradesh, Maharashtra and Goa). The first picking starts in 60-65 days after transplanting, bears more than 100 fruits/plant, fruit weight is 100 g and has yield potential of 550-580 q/ha. This hybrid is resistant to little leaf disease.

Arka Neelachal Yodha is a pure line selection. The plants are tall, erect and vigorous. Fruits are green with white patches having green calyx, oblong and medium in size (90 to 110 g/fruit). It has productivity potential of 45 to 50t /ha with high resistance to bacterial wilt (*Ralstonia solanacearum*).

Amaranth: Arka Neelachal Ruchitha is a multi-cut type, fleshy tender yellowish green stem with obovate green small leaves having 22.59 t/ha yield potential and resistant to white rust (*Albugo bliti*).

Arka Neelachal Vrichitha is a pulling type variety with fleshy tender greenish pink stem with ovate green leaves having purple blotches, suitable for cultivation during rabi and pre-summer season. It has resistance to white rust with yield potential of 7.08 t/ha.

Arka Neelachal Bainishi is a pulling type variety with fleshy tender pink stem, pink petiole with greenish purple leaves suitable for growing during *rabi* and pre-summer season. It is resistant to white rust having potential productivity of 8.58 t/ha.

Cucumber: Hybrid- Kashi Nutan has been identified for cultivation in zone-IV (Uttar Pradesh, Bihar, Punjab, Jharkhand) in 2021. The fruits are light green, tolerant to cucumber mosaic virus and downy mildew and has crispy flesh free from carpel separation. Average fruit weight 200-225g with good market acceptability. Productivity is 165-180 q/ha.

Okra: VRO 111 (Kashi Sahishnu) has been identified for cultivation in Uttar Pradesh, Bihar, Punjab and Jharkhand. It takes 40-45 days for first flowering at 5-7 nodes with fruiting period of 45 to 110 days. It bears 12-14 cm long, dark green fruits free from pubescence. It is highly resistant to both YVMV and ELCV. Yield potential is 140-150 q/ha.

VRO 119 has been identified for cultivation in zone-VI (Delhi, Haryana, Rajasthan, Gujarat). It takes 45-50 days for first flowering at 6-8 nodes with fruiting period of more than 120 days. It bears 11-13 cm long, green fruits free from pubescence. It is highly resistant to both YVMV and ELCV. Yield potential is 160-180q/ha

Sem/Indian bean: VRB SEM 207 has beenidentified for cultivation in Zone- IV (Uttar Pradesh, Bihar, Punjab, Jharkhand) & Zone VI (Delhi, Haryana, Rajasthan, Gujarat). It has green pods and tolerance to Dolichos Yellow Mosaic Virus (DYMV). The first picking starts at 80-85 days and last pickling in 135-140 days after seed sowing. Pod length is 11.4 cm and width is 2.52cm. The pod weight 9.13 g with good market acceptability.Yield is 27.78 q/ha.

Thar Kiran has been identified as a unique sem variety with attractive purple pigmentation on stem,

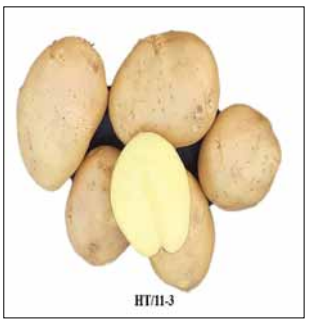
petiole, flower, leaf veins and pod. It has climbing growth (3.5 to 4m). Pod harvesting starts at 100-110 days after sowing with 1100-1600 pods weighing 7-9kg/plant. It has potential productivity of 60-63 t/ha fresh pods. Pod contains anthocyanins 190mg/100g, lycopene 1.5mg/100 g, proteins 5.4 g/100 g, total phenols 376.5 mg GAE/100 g, flavonoids 40.6 mg catechin equi/100 g, ascorbic acid 8.94 g/100 g and total antioxidants activity 662.5 mg AAE/100 g.

Muskmelon: Thar Mahima is suitable for spring-summer sowing in open field (mid February.) and low tunnel (last week of December to 1st January) condition for hot arid climate. This variety has short vine length (1.6 to 2m), early in harvesting (75-80 DAS), desirable fruit weight (780-900g), low seed cavity (4.27-5.58 cm) and productivity 193.7q/ha. Fruit pulp TSS ranged from 11.5- 11.8°B and shelf life 4-5 days at room temperature.

Cassava: Sree Kaveri has resistance to cassava mosaic disease (CMD) and field tolerance to moderate soil moisture deficit. It is a high yielding (50-60 t/ha) with 27.5% increase over local check with potential yield up to 100 t/ha. It has 28% starch which is good for industrial purpose. Recommended for cultivation in Kerala, Tamil Nadu and Andhra Pradesh.

Potato: MP/09-45 has been identified for cultivation in the Northern, Central and Eastern plains of India. The clone has white cream ovoid tubers with shallow eyes and creamy flesh. The average yield of the clone is 35 t/ha and tuber dry-matter of 21%. The clone is medium maturing (90-100 days). It is suitable for processing into chips.

HT/11-3 is heat-tolerant variety with white cream peel, creamy pulp, oval and shallow eyes on tubers. The tuber productivity of the clone is 35 t/ha which was 18% higher than the present heat-tolerant variety Kufri Surya and 12% higher than Kufri Kiran. The clone is early medium to medium (85-90 days) maturing. It possesses 19% tuber dry-matter and has tolerance to mite and hopper burn, which are the primary insect-pests during early-season crops. It has been identified for Utter Pradesh, Haryana, Punjab, Uttarakhand (early crop planting) Chhattisgarh, Gujarat, Rajasthan and Odisha (main crop planting). Therefore, this variety is recommended for potato production as the early crop in northern plains of India and as the main crop in central blainsh and plateau regions.



WS/07-113 has been identified as a climate resilient variety with field tolerance to less soil moisture stress and recommended for cultivation in Central and Eastern plains of India. It has white cream ovoid tubers with cream flesh. The productivity of this variety is 32 t/ha under water stress conditions. The clone is medium maturating (90-100 days).

Tannia: TTn 14-1 (IGSGTN 1) has 30% higher (12.16 t/ha) productivity than the local check (8.7 t/ha) and identified for cultivation in Chhattisgarh, Manipur and Kerala**.**

TTn 14-5 (XaMTS Local) has 39% higher (14 t/ha) productivity than the local check (10.08 t/ha) and identified for cultivation in Kerala.

Taro: BCST 14 recorded 21.56% higher (19.34 t/ha) stolon yield than the local check (15.17 t/ha) and recommended for cultivation in West Bengal, Assam and Manipur. AAUST 2 recorded 33.73% higher (26.97 t/ha) caudex yield than the local check (20.04 t/ha) and recommended for state release in Assam.

Harvested stolons for marketing (BCST 14)

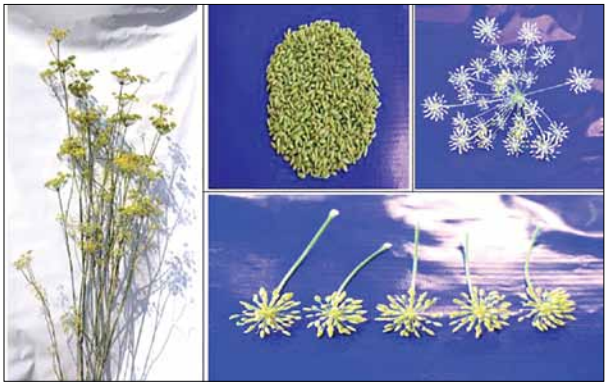
Corms and cormels of tannia variety IGSGTN-1

Spices

Small cardamom: Appangala 3 is a moisture stress tolerant cardamom genotype with 550 kg dry capsules/ha productivity under irrigated, conditions and 360 kg dry capsules/ha under moisture stress conditions. The 50% of the capsules are of > 8 mm size. Essential oil content varies from 8.74% (irrigated, conditions) to 8.84% (moisture stress conditions). Drought susceptibility

index is 0.89 and drought tolerance efficiency is 70.71%. There is not much change in the composition of α-terpinyl acetate and 1,8 cineole under irrigated, and moisture stress conditions.

Fennel: JF 2013-19 (GF 13) is high yielding (21.12 q/ha), which is 14.8 and 10.7 per cent higher seed yield over National checks, viz. RF 205 and RF 101, respectively. It contains high volatile oil yield (40.75 l/ ha) withbold seed (test weight 6.33g). It is moderately resistant to Ramularia blight disease.



Flowers and Other Ornamental Plants

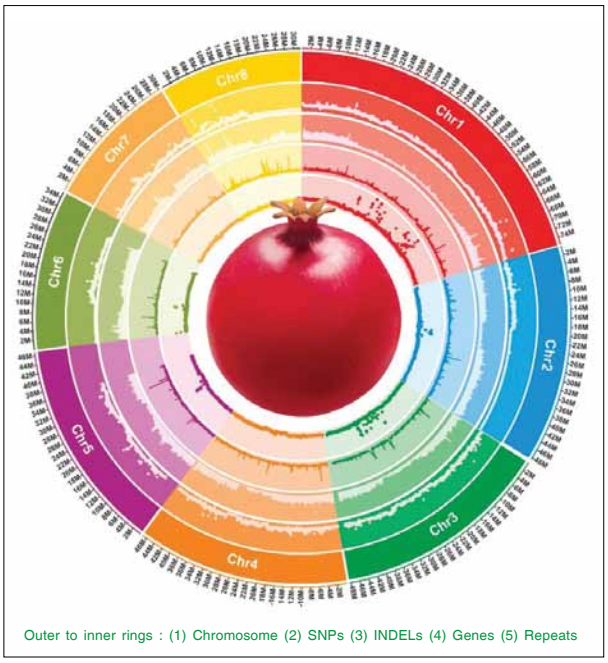
Tuberose: Arka Keerthi produces single type flowers on tall spikes, the flower buds have a green tinge on the tip with a greater number of flower buds per unit (kg). Flowers are medium in size with the matured bud weight of 1.29g. It bears more number of spikes (8.4) and bulbs (8.94) per clump per year. It has high loose flower yield (18.88 t/ha/year), field tolerant to nematode and leaf burn disease.

Biotechnology

Molecular linkage maps of Grape varieties: Molecular linkage maps were developed for two grape varieties. SNP marker-based linkage map developed for Carolina Black Rose consisted of 1716 SNP markers covering a total distance of 2219.96cM with an average distance of 1.29cM, whereas, Thompson Seedless consisted of 1308 SNP markers covering a total distance of 1453.46cM with an average distance of 1.11cM. QTL mapping based on SNP and phenotyping data of fifty hybrids of Carolina Blackrose and Thompson Seedless identified several QTL regions for berry weight and berry size. Association mapping analysis to identify the molecular markers linked to bunch architecture related traits identified 22 marker trait associations. SNP marker S5_4053397 on chromosome 5 showed association with bunch length, bunch width, bunch volume and berry weight. The linked markers are being validated in segregating population.

Release of reference quality genome assembly of Indian pomegranate cv. Bhagawa: The assembly of the sequences resulted into a high-quality genome of pomegranate cv. Bhagawa. The reference-quality genome assembly of 346.08Mb was assembled in 342 scaffolds having an average N50 of 16.12 Mb. This assembly covered more than 98% of the estimated size (352.54 Mb) of the pomegranate genome. The LTR Assembly Index (LAI) value of 10 and 93.68% BUSCO completeness score over the 1440 ortholog genes of the finished pomegranate genome displays the quality of the assembled pomegranate genome. Further, 29,435 number of gene models were discovered with a mean transcript length of 2954bp and a mean coding sequence length of 1090 bp. Further, about 1,573 disease resistance protein coding genes, and 1,533 transcription factor (TF) coding genes and 314 MIR ncRNA genes that code for 26 different families of microRNAs which regulate various genes for growth and developments of pomegranate plant were also discovered.

Chromosome level assembly of Indian pomegranate cv. Bhagawa: The chromosome level assembly using HiC- chromo some conformation capture sequencing for the var. Bhagawa genome to assemble the entire genome into eight chromosomes was done. The libraries were prepared by using Genomics Proximo kit and sequenced by using Illumina NovaSeq 6000 platform. A total of 345 Mb of genome was covered having the presence of 33003 genes with 41682 mRNAs.



Chromosome Level assembly of pomegranate cv. Bhagawa

Varietal signature for genetic purity of spices: The unique ISSR markers for distinguishing *Pimenta dioica* from *Pimenta racemose* were identifiedand identity of nutmeg varieties IISR Vishwashree, IISR Keralashree and Sindhushree established. The SNP based DNA barcoding of rbcL loci was done to distinguish *Cinnamomum verum* from *C. cassia* for authentication of samples from farmer's field.

Marker free late blight resistant transgenic line KJ 66 of potato: The mendelian pattern of segregation of RB event SP 951 in potato Kufri Jyoti progenies revealed marker and plasmid backbone free KJ 66 line in

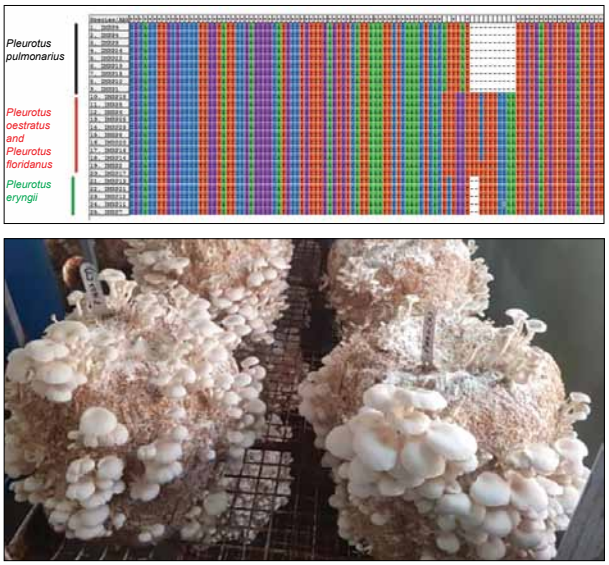
Targeted Editing of Potato Genome to Develop Variety Specific True Potato Seed (TPS)

A total of 16 lines of potato with mutation within MiMe genes (*StOSD*, *StREC8* and *StSP011*) were generated. Further, 14 independent events with mutation in target region of *CENH3* gene were selected and crossed with control Kufri Jyoti plants for evaluation of haploid induction efficiency. The obtained TPS were germinated and screened for haploid induction efficiency using FACS and Sanger sequencing. The haploid induction efficiency ranging between 10-15.7% was observed in five *CENH3* edited lines of potato.

Kufri Jyoti background. The line was selected to conduct the Biosafety research trial for evaluating the field resistance to late blight disease. The event KatSP951 was crossed with cultivar Kufri Jyoti and approximately 1,000 hybrid true potato seed were obtained and progeny F_1 plants were screened for the presence of the Rpi-blb1 and nptII-containing inserts. The progeny line KJ 66 of potato was identified as containing only the Rpi-blb1 insert on chromosome 4.

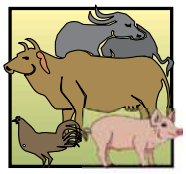
Generation of functional genetic resources for nutrient rich potatoes using activation tagging: A total 1047 activation tagged lines were generated in potato cv. Kufri Jyoti and Kufri Chipsona using activation tagging vector pSKI015. Altered morphological and physiological traits, including multiple main stem formation, high tuber yield, deformed and elongated tuber shapes and enhanced nutrition were observed in selected activation tagged lines. The positions of T-DNA insertion in different lines was also identified using genome walking technique.

Genetic improvement of oyster mushroom: Molecular identification and diversity of 25 *Pleurotus* mushrooms were investigated. Based on their banding profile, a total 219 polymorphic bands were detected. Unweighted Pair-Group Method with Arithmetic Mean (UPGMA) based dendrogram was created and diverse strains were identified. The eight cross combinations were identified viz. DMRP 7 × DMRP 11, DMRP 4 × DMRP 19, DMRP 3× DMRP 19, DMRP 1 × DMRP 19, DMRP 2 × DMRP 8, DMRP 2 × DMRP 14, DMRP 2 × DMRP 25 and DMRP 18 × DMRP 23 for genetic improvement in future breeding.



P1802, (hybrid of DMRP 49 and DMRP 30)

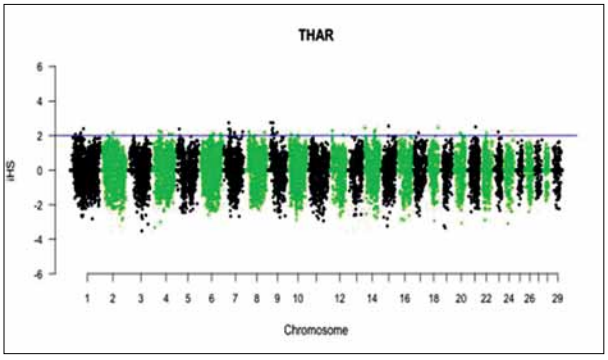
DNA Barcoding profile of four mushroom species of ITS rRNA gene of *Pleurotus* using MEGA: Seven new hybrid strains of *Pleurotus* were developed by mating single spores from *Pleurotus ostreatus* (DMRP 30) and *Pleurotus* florida (DMRP 49). The maximum biological efficiency was recorded for hybrid P18102 (79.00%) in two flushes compared to parents and check on pasteurized wheat straw. ❑



3. Livestock Improvement

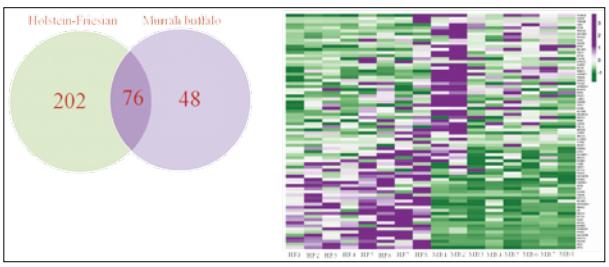
Cattle/Buffalo

Selection signatures in Indian and exotic cattle breeds: The evidence of selection signatures in the datasets of 284 individuals of Tharparkar cattle along with 11 other indigenous and exotic cattle breeds were demonstrated. To find out these genomic regions were due to selective sweeps, eight different statistical tools were used. Significant candidate genes were identified related to various important traits such as *ADRB2* in Tharparkar; *HERC5*, *SCC25A48* in Gir; *CA8* in Ongole and *KIAI217* in Sahiwal for milk production; *PARN* in Holstein; *ZBTB20* in Sahiwal; and *APBB1* in Tharparkar for reproduction; *SP110* in Brown Swiss; *HSP90AB1* in Tharparkar and Red Sindhi for thermo-tolerance trait.



Selection signatures in Tharparkar cattle breed

Expression of X-linked genes: The influence of X-linked genes on the sperm functional parameters and field fertility rate in the cattle and Murrah buffalo bulls was studied. The sperm transcriptome studies revealed that the total number and the expression levels of X-linked genes in the mature sperm were very low in both species, and only 23.3% of these genes were commonly expressed between them. The X-linked genes related to embryonic organ development and reproduction were enriched in cattle and buffalo sperm, respectively. The expression levels of X-linked genes *RPL10* and *ZCCHC13* in cattle, and *AKAP4*, *TSPAN6*, *RPL10* and *RPS4X* in buffalo were significantly correlated with sperm kinematics.



Comparison of the X-linked genes expressed in sperm of Holstein-Friesian cattle and Murrah buffalo

Evidently, the expression level of *RPL10* and *RPS4X* was significantly correlated with the field fertility rate in cattle and buffalo, respectively. Multivariate regression models and receiver operating curve analysis suggested that the expression levels of X-linked genes may be useful in predicting the bull fertility rate.

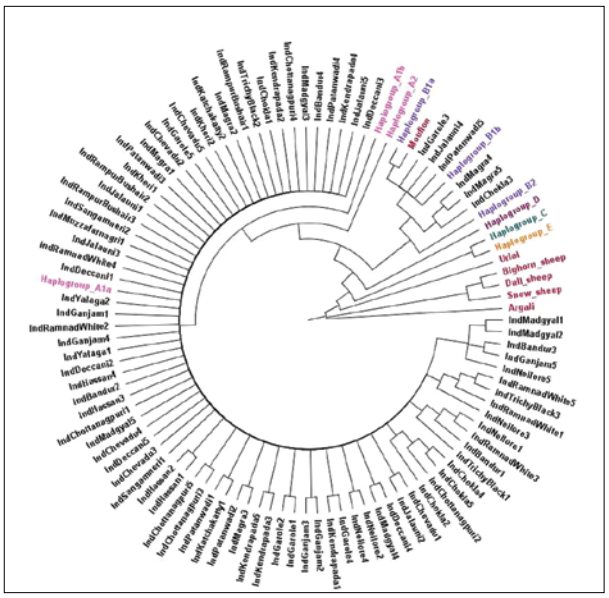
Egg yolk free semen extender: Developed an egg yolk-free, ready to use, semen extender for cattle and buffalo with higher shelf-life (≥18 months, 4°C) for cryopreservation of buffalo semen. The post-thaw progressive motility of cryopreserved buffalo sperm in the new egg-yolk free semen extender was significantly higher (total motility: 68.6±5.62%; progressive motility: 41.5±4.01%) as compared to that of traditional egg-yolk-based semen extender (total motility: 41.6±2.55%; progressive motility: 18.7±1.70%).

Ready to use egg yolk-free semen extender for buffaloes

Buff trace: A farm-to-fork block chain based buffalo meat traceability system was developed for buffalo meat industry in collaboration with the Chainflux Pvt Ltd., Bengaluru. The system helps in collection of post-slaughter information and retrieval of the traceability information based on the label details.

Sheep

Whole mitogenome based genetic diversity analysis of Indian sheep: The complete mitochondrial genome sequences of 88 Indian sheep representing 22 breeds/population were analyzed to get a comprehensive picture of the maternal diversity in the sheep genetic resources of India. The mitochondrial DNA sequence of all Indian sheep was observed to be 16,617 bp long and contained 37 genes, including 13 protein coding genes, 2 rRNA genes, 22 tRNA genes, and a control region. With the exception of NAD6 gene and eight tRNA genes, all other genes were encoded on the heavy strand of the mitogenome. Sequence analysis of all 88 samples yielded a total of 84 novel haplotypes



Phylogeny of mitogenomes of Indian breeds in relation to known ovine haplogroups

in Indian sheep, with an overall haplotype diversity (Hd) value of 0.999, and nucleotide diversity (π) equal to 0.00183. The AMOVA analysis between the four separate clusters representing northern temperate, southern peninsular, eastern and north-western arid and semi-arid regions attributed maximum genetic variance within the clusters and less variance between the clusters. Phylogenetic relationships based on ovine haplogroups (A-E) revealed clear separation of domestic sheep from the wild ones. Indian sheep showed conformity to haplogroups A and B reported across the world.

Avishaan sheep: The prolificacy in Avishaan ewes was 70.79% with litter size of 1.91. The average daily milk yield in ewes during the autumn lambing was 814 g. Since last four years, lambs born were 100% *FecB* gene carrier suggesting segregation of *FecB* gene in the progenies as a major gene. In field units of Avishaan, a total of 64 lambs were born out of 36 lambing of Avishaan ewes with a prolificacy of 75% and litter size of 1.80.

Network Project on Sheep Improvement (NWPSI): The NWPSI aims at genetic evaluation and continuous improvement of indigenous sheep breeds through selection for better growth and wool production. The project includes four farm and two field based cooperating centres located in various ICAR Institutes and State Agricultural/Veterinary Universities.

A total of 425 male and 142 female sheep of different breeds were sold for genetic improvement of farmer's flock.

Genetic resources maintained at CSWRI

Sheep breed	Rams	Ewes	Total strength
Marwari	147	404	551
Muzaffarnagari	145	441	586
Deccani	162	274	436
Nellore	116	332	447
Total	570	1451	2021

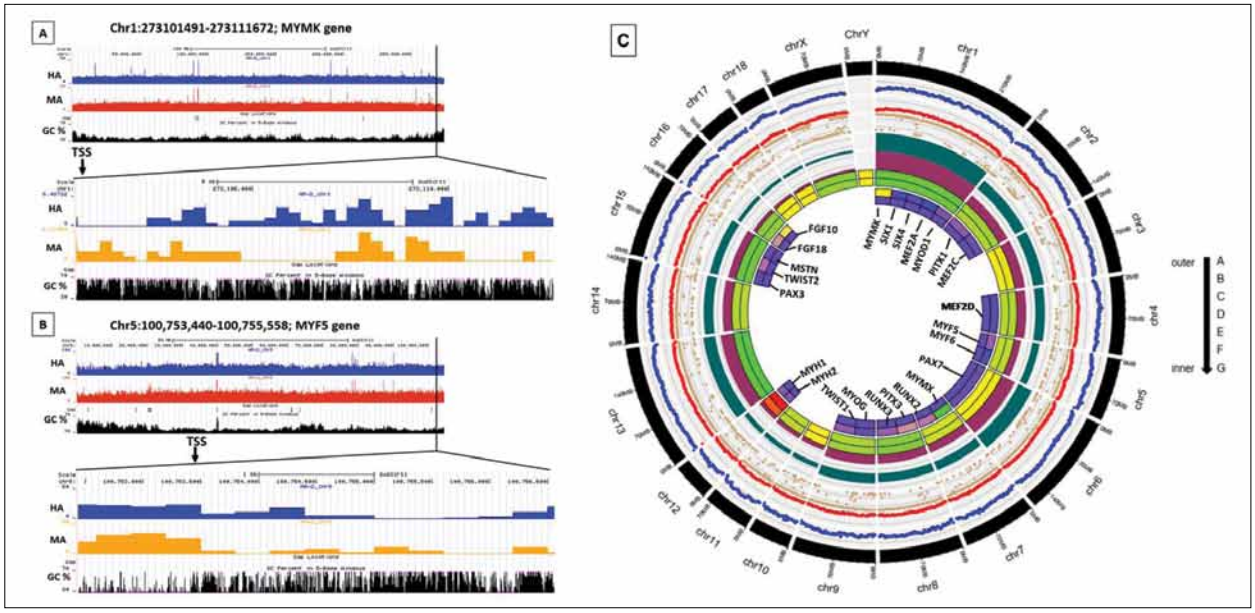
Mega Sheep Seed Project (MSSP): The project has four cooperating units: KVAFSU, Bidar for Mandya Sheep; TANUVAS, Chennai for Mecheri Sheep; RAJUVAS, Bikaner for Sonadi Sheep and ICAR-CSWRI, Avikanagar for Malpura sheep. The major objective of the project is improvement of indigenous sheep breeds by propagation of superior germplasm in the farmers' flock by production and distribution/sale of 70 superior breeding rams to cover at least 2,500 breeding ewes of farmers annually by each unit.

Flock of Madras Red sheep

Pig

Concurrent transcriptome and methylome analysis of pig breeds with varying muscularity to obtain insights into myogenesis: In Mali and Hampshire breeds of pigs with divergent muscularity, muscle transcriptome and methylome data was integrated with histology, immunofluorescence and meat yield to identify difference between breeds during early growth phase. Muscle transcriptome identified 20,226 mRNAs out of which 15,170 were across the samples. Expression of genes related to early determination (*MYF5*, *MYOD1*) and myoblast fusion (*MYMX* and *MYMK*) were higher in Hampshire than Mali even though levels of several myogenesis related genes (*MYF6*, *MYOG*, *MSTN*) were similar. During the study, 1,549 differentially methylated regions were identified. The number of fibres per fascicle and expression of myogenic marker proteins (MYOD1, MYOG and PAX7) was more in Hampshire as compared to Mali breed of pig. Common transcripts both in Mali and Hampshire muscle samples revealed enrichment of genes (>1.5 fold enrichment) related to various myogenic process.

Developed economic and nutritionally balanced silage based pig feed: Silage was prepared following standard procedure from vegetable wastes adding



Methylation of genome in relation with expression of myogenesis associated genes: (A) Methylation in the promoter region of *MYMK* gene in Mali as compared to Hampshire breed of pig; (B) No difference in the methylation in the promoter region could be observed with respect to *MYF5* gene; (C) Circos plot showing genome wide methylation in Mali and Hampshire breed of pigs

jaggery (gur) at the rate of 3 kg per 100 kg raw chaffed vegetable waste for suitable anaerobic fermentation in silage bags. Vegetable waste silage had DM, CP, EE, CF, NFE and ash as 67.5, 18.25, 1.95, 18.5, 49.1 and 12.2% on DM basis, respectively. The *in vitro* DM digestibility was found as 69.34, 67.26 and 65.61% respectively for feeds containing 8, 10 and 12% crude fibre (CF) level.

Artificial Insemination at farmers' field: A total of 1,934 liquid boar semen doses were produced and supplied for artificial insemination in pigs at the farmers' field and organized farms.

Poultry/Duck

Improved poultry varieties for sustainable poultry production: To achieve climate resilient poultry farming goal, three climate resilient dual type hardy birds for efficient egg and meat production were developed. This will help in increasing farmer's income by maximizing production throughout the year without compromising bird's welfare.

CARI-Dhawal (Frizzle plumaged cross of Desi with WLH): The dual type climate resilient white plumaged cross was developed for efficient egg production in intense summers/tropical conditions. Its laying capacity is about 260-275 eggs per annum.

CARI-Prabal (cross of Aseel): Birds are active, large in built, pugnacious in nature. They are able to save themselves from their predators due to their fighting characters and activeness and are adapted to all climatic zones of the country. Its laying capacity is around 170-190 eggs per annum.

Production characteristics of CARI-Dhawal, CARI-Prabal and CARI-Saloni

Attribute	CARI Dhawal	CARI Prabal	CARI Saloni
Body weight at 20 weeks (Male)	1811 g	1788 g	1696 g
Body weight at 20 weeks (Female)	1221 g	1474 g	1316 g
Age at sexual maturity	149 days	178 days	187 days
Annual egg production	274	190	195
Egg weight at 40 weeks	52 g	52 g	50 g
Fertility	91%	89%	86%
Hatchability (FES)	84%	83%	82%

CARI-Saloni (cross of Kadakanath): These birds are with plumage colour dominated by black. The skin, beak, shank, toes and soles are dark gray colour with muscle and most internal organs having black pigmentation due to deposition of melanin pigment. Its laying capacity is about 170-195 eggs per annum.

Rural poultry: The six-weeks shank length and body weight (851.0±3.15g) in PD-1 line (*Vanaraja* male line) increased significantly compared to last generation. The genetic and phenotypic response in shank length at 6 weeks of age was 0.83 and 0.72 mm per generation over the last 15 generations. In PD-6 line (*Gramapriya* male line), the egg production up to 40 weeks was 64.57±020 eggs with an egg weight of 55.53±0.02 g. In PD-2 line (*Vanaraja* female line), the egg production and egg weight at 52 weeks were 130.6±0.98 and 55.88±0.04, respectively. In S-18 generation, the body weight and shank length at 6 weeks of age were 701.7±4.98 g and 77.32±0.001 mm, respectively. In the PD-3 line (*Gramapriya* female line), the egg mass at 40 and 64 weeks of age was 5547±1.74 and 12369±4.06 g, respectively, which increased significantly from the last generation. The genetic and phenotypic response for egg mass at 40 weeks was 611 and 739 g, respectively over the last 9 generations.

Adult birds of PD-6 line

Adult male of PD-3 line

Adult male of PD-1 line

Feed supplement to replace antibiotic growth promoter and reduce thermal stress

- ***CARI–HERBIGROW*:** Antibiotic growth promoters, used in poultry feed are major concern for growing antibiotic resistance. To overcome this problem, CARI-HERBIGROW, a natural product was developed by ICAR-CARI using various herbs which has property of antioxidants, is an immune enhancer, stress reducer and helps chicken to improve overall production. The product was released by Secretary DARE and DG, ICAR on October 29, 2022.

- ***CARI – HERBISTRESSMIN:*** It is a phytogenic feed additive developed by CARI to reduce effect of heat stress as well as to improve immunity of birds during hot and hot-humid summer. The formulation contains phyto-constituents like polyphenols, beta-carotene, limonene, flavonoid Vitamin C, Vitamin A, folate, calcium, magnesium and potassium. This phytogenic feed additive can be directly added to the poultry feed. This was released by Secretary, DARE and DG, ICAR.

- ***Amelioration of transportation stress by anti-stress supplementation and lairage environment for better meat quality and welfare of broiler chicken during summer:*** An anti-stressor was developed to improve overall welfare and to reduce drip loss during transport which needs to be given to birds in drinking water three days prior to transport. Supplementation of the anti-stressor results into 3% less drip loss in transported birds. Also, the overall welfare parameters were found significantly better in the supplementation group than in the control.

- ***Alternatives for antibiotic growth promoters (AGPs) in feed*:** Herbal agents like marigold phenols (MP), marigold lutein (ML) and oregano extract (OE) (250 g/ton of feed) or coated sodium butyrate (250-500 g/ton) in broiler diet were found similar or better than bacitracin methylene disalicylate. Further, supplementation of feed emulsifier (combination of lecithins, glyceryl polyethylene glycol ricinoleate, glyceryl monostearate and polyoxyethylene sorbitan monooleate) in diet (250, 250 and 500 g during pre-starter, starter and finisher phases) also yielded similar broiler performance in comparison to those fed AGP. Supplementing enzymes (protease, phytase and xylanase in combination) also ensured optimum broiler chicken performance in the absence of AGP in feed.
- ***Alternate protein meal and biofortified maize in poultry diet*:** Black soldier fly (BSF) larva meal, when tested in the diet of chickens on iso-caloric and iso-nitrogenous basis, was found to be a good source of protein, with beneficial effects on growth during the initial few weeks of life (up to 5% in the diet of broiler chicks and up to 12% in the diet of Vanaraja chicks). Feeding of low-phytate maize variety having 71% lower phytate content improved body weight gain, feed conversion efficiency and bone breaking strength in Gramapriya chicks in comparison to normal maize.
- ***Plant-mediated green synthesis of zinc and copper nano-particles and their evaluation in poultry diet*:** Of different plants screened, six plants (leaves of moringa, neem, mango, red sandalwood and guava, and aloe vera gel) showed promising results in producing nano Zn particles (10.84 nm). In the diet of Vanaraja chicks, nano Zn thus produced was tested at graded levels in place of inorganic mineral source. Nano Zn even at 25% level as that of inorganic Zn supported optimum performance of Vanaraja chicks and improved immune response. Similarly, copper nano-particles (9.62 nm) were produced using neem leaves extract and were found to improve immune response in Vanaraja chicks without affecting their performance.

Gene editing by CRISPR/Cas in Nicobari indigenous chicken: *Inhibin alpha* gene was edited by CRISPR/Cas in Nicobari chicken. The efficiency of production of transgenic birds was 21.7 and 7.6% for exon1 and exon2, respectively, while efficiency of production of inhibin alpha edited birds was 13% for exon1 only. The egg production up to 72 weeks of age was significantly higher by 103.9% in edited birds as compared to the control birds (261 vs 128 eggs). Egg quality (Haugh unit and yolk colour index) was better and the serum levels of reproductive hormones were higher in the edited birds.

Rapid detection kit for authentication of chicken: Immunochromatography-based chicken detection kit (ICDK) was developed for the authentication of chicken.

The kit contains extraction buffer, pestle and mortar for extraction of target analytes, assay strips and the entire test can be performed in any resource-limited settings within 15 min. The developed kit is highly sensitive, species-specific and can be stored at ambient temperature for 2-3 months. Each test costs approximately ₹35.00.

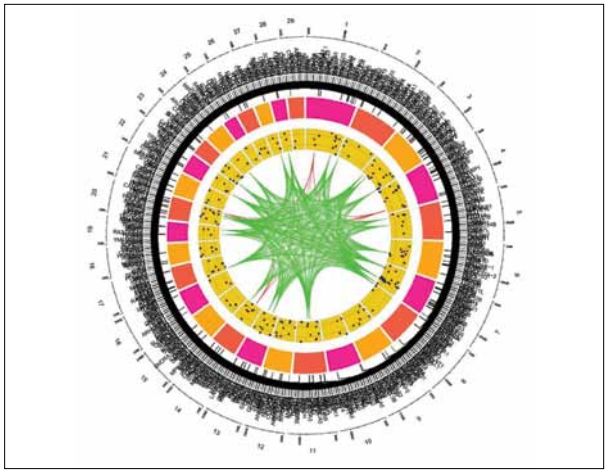
Duck

In the S-1 generation of Kuzi (native duck) population, the egg production up to 72 weeks of age was 218±5 eggs and the egg weight was 71.29±0.30 g. In the next (S-2) generation, there was an increase of 125 g in 8 weeks body weight. The shank length and keel length of cross KD (Khaki Campbell × Kuzi) recorded at 8 weeks of age were 69.28±0.51 and 129.5±1.01 mm, respectively. Corresponding shank length and keel length in DK (Kuzi × Khaki Campbell) were 71.80±0.43 and 125.8±0.82mm, respectively. The growing period body weights were higher in Kuzi compared to the crosses. The egg production up to 40 weeks of age in Kuzi, KD and DK crosses was 110.2, 123.4 and 130.6 eggs, respectively and the corresponding egg weights were 71.23±0.16, 68.61±0.45, 67.68±0.28 g. Besides, research efforts have been initiated for developing aflatoxin-tolerant duck population.

Adult ducks (DK cross)

Yak

Genomic diversity in Arunachali yak population: Inbreeding poses a major challenge for yak conservation and genetic improvement. Genomic diversity was estimated in Arunachali yak population based on data generated using ddRAD sequencing. Three indices, viz.



Circos plot depicting putative regions of selective sweep

nucleotide diversity (0.041 in 200 bp windows), effective population size (Ne = 83) and runs of homozygosity (>90% were short and medium length) revealed that the genomic diversity in Arunachali yak breed as of now is optimum.

Selection signatures in Arunachali yak genome: Yak has been extensively exposed to natural selection as a part of its environmental adaptation in cold and hypoxic conditions. In order to identify the selection footprints or selection signatures in Arunachali yak genome, different test statistics were generated from genomic data. It was found that Arunachali yak genome has been selected for platelet aggregation and olfactory perception, both of which are adaptive mechanisms to explain the evolutionary processes in Arunachali yak genome.

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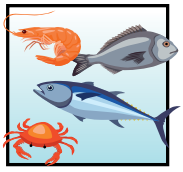
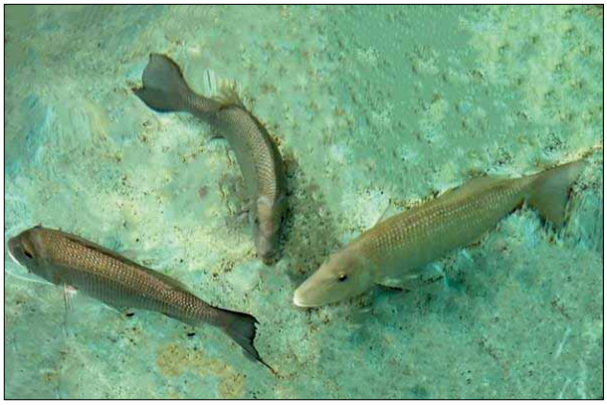


4. Fish Improvement

Breeding and rearing of fishes under controlled conditions: Successful natural spawning of green snapper, *Lethrinus nebulosus* (Forsskal 1775) was achieved in recirculatory aquaculture system (RAS) in ICAR-CMFRI, Regional Centre, Vizhinjam. It is a large tropical marine fish species that grows to 80 cm in length and 8.4 kg in weight. *L. nebulosus* were collected from wild and developed into functional broodstock in 10 t RAS system. Fishes were allowed to spawn naturally in RAS. Fertilized eggs were planktonic, spherical, with a single oil globule. Green water medium with combination of algal species was used for larval rearing. Copepod nauplii were used as the first feed, followed by rotifer and artemia in later stages and then were weaned to artificial diet. Metamorphosis of larvae started by 30 dph at a total length of 2.3 cm, and it was completed by 40 dph. A flow-through system was adopted for further rearing, which improved the survival at the metamorphosis stage.

Simple non-invasive breeding and culture protocols were developed for four indigenous ornamental fishes of the Western Ghat, commonly known as indigo barb, is found in streams flowing westward in Maharashtra, Karnataka and Goa. Breeding protocols were successfully developed for *P. setnai* and *P. nigripinnis*, with M/F sex ratio of 1:1. Similarly, breeding technique were standardized for two endangered species viz. *Dawkinsiatam braparniei*, the Tambraparniei barb and *Dawkinsia arulius*, the Arulius barb.



Bloodstock of *Lethrinus nebulosus*

Two backyard recirculating aquaculture system (RAS) models of rearing tanks size 3 and 7 m^3 with production capacity of 30 kg per m^3 were designed, fabricated and validated for small-scale farming of

SUCCESS STORY

'CIFA-GI Scampi' revolutionizing giant freshwater prawn farming

'CIFA GI Scampi', is a genetically improved and fast-growing strain of giant freshwater prawn/scampi, *Macrobrachium rosenbergii* developed through selective breeding by ICAR-CIFA. To further boost its farming, during 2021-22, ICAR-CIFA signed MoU with five multiplier hatcheries in Andhra Pradesh. So far, over 2 million seed of GI scampi have been produced by these multiplier hatcheries and supplied to farmers.

Under field trial, a fish farmer, Shri Bata Krushna Jena from village Nishimala, block Badachana, district Jajpur, Odisha cultured 'CIFA-GI Scampi' in carp-scampi polyculture in his 0.10 ha pond. In July 2021, he stocked 1500 post larvae (0.114±0.01 g) of CIFA-GI Scampi, and fish yearlings- 200 catla (160±5.4 g) and 500 rohu (104±6.5 g), 500 grass carp (83±4.88 g) and 100 black carp (75±3.53 g), maintaining the stocking densities of 15,000 prawn post larvae and 13,000 fish yearlings per ha. After seven months of culture period with regular feeding of 5 to 2% of body weight, the final harvesting was done in February 2022. Obtained a yield of 95 kg CIFA-GI scampi of average weight of 72 g and 753 kg of carps and Feed Conversion Ratio (FCR) was about 1.56.

Total expenditure incurred during culture period of seven months was ₹ 92,940 and total revenue generated from sale of fish and prawn was ₹ 1,43,420. Hence, the net profit achieved from carp-scampi polyculture from 0.1 ha pond was ₹ 50,480 in seven months. The profit earned from sale of CIFA-GI Scampi was ₹ 32,000 which accounts for 2/3rd of the total profit (₹ 50,480) earned in carp-scampi polyculture system. The present trial establishes the advantage of CIFA-GI Scampi in increasing production as well as profit.

Farmer showing the harvest of CIFA-GI Scampi and carp from the carp-scampi polyculture system

rainbow trout by the farmers of hill states to reduce the initial cost of investment. When rainbow trout fingerlings of 50 g and 70 g were reared in tanks of 3 and 7 m^3, respectively, attained marketable size of 700 g in 150 and 180 days, respectively in both the systems. The techno-economic feasibility study showed that both systems had pay-back period of 2-3 crops (1-2 year) and water usage was 908-1,082 L per kg fish produced, which is 50-100 times lesser than the flow-through system.

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5. Genetic Resources

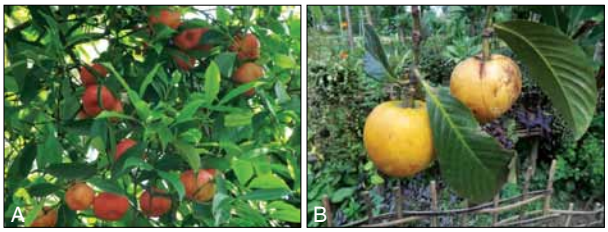
Plant Genetic Resources

Germplasm exploration: During the period under report, a total of 18 explorations were undertaken and 890 accessions (450 cultivated and 440 wild) were collected from parts of Assam, Bihar, Chhattisgarh, Gujarat, Jammu, Himachal Pradesh, Jharkhand, Lakshadweep, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Rajasthan, Sikkim, Uttarakhand and West Bengal. Collected germplasms included unique landraces of cereals, pulses, oilseeds, vegetables and germplasms of wild edible fruits and crop wild relatives. Germplasms of fruits, viz. *Aegle marmelos* (43), *Annona reticulata* (17), *Buchanania lanzan* (37), *Carissa carandus* (3), *Citrus medica* (6), *Citrus aurantium* (4), *Citrus macroptera* (4), *Citrus grandis* (9), *Citrus jambhiri* (14), *Citrus reticulata* (8), *Diospyros melanoxylon* (5), *Garcinia pedunculata* (5), *G. xanthochymus* (3), *G. lanceifolia* (2), *Moringa concanensis* (54), *Moringa oleifera* (41) and wild relatives of cultivated crops, viz. *Oryza sativa* f. *spontanea* (19), *O. nivara* (10), *O. rufipogon* (19), *Cajanus scarabaeoides* (12), *Abelmoschus tetraphyllus* (19), *Abelmoschus tuberculatus* (11), *Abelmoschus ficulneus* (1) and *Luffa acutangula* var. *amara* (7) etc. were the significant collections.

A total of 572 herbarium specimens were processed (in addition to 579 virtual herbarium specimens) including 14 new taxa that were added to the National Herbarium of Cultivated Plants (NHCP), ICAR-NBPGR, New Delhi bringing the holdings to a total of 25,578.

Germplasm conservation: Germplasm added to the National Genebank for long-term storage comprised 5,152 accessions of orthodox seed species and currently the base collection of National Genebank has a total of 4,62,923 accessions. A total of 24 accessions of fruits, tubers, bulbs and medicinal plants were added to the *in-vitro* Genebank, making the total collection of 1,952 accessions in the form of ~39,500 *in vitro* cultures of 54 genera and 150 species. In the Cryogenebank, 404 accessions of seeds and pollen genomic resources of different crop species were successfully cryopreserved, making the total collection of 12,480 accessions belonging to 860 species, besides 2,194 genomic resources.

(A) Spike of *Parwapank* landrace collected from Supaul district, Bihar, (B and C) single caryopsis fruit and (D) single grain.



(A) *Garcinia pedunculata*, (B) *G. lanceifolia* collected from Tinsukia district of Assam.

Variability in bael fruits collected from Achanakmar Amarkantak Biosphere Reserve, Chhattisgarh.

Germplasm exchange: A total of 41,557 accessions were imported from 37 countries. Additionally, 14,641 entries (1,07,265 samples) were imported from trials/ nurseries from CG Centres. Important trait specific accessions that were imported are as follows: *Barley*: Variety Golden promise is a heritage variety (1130766-67/USA) with distinct brewing and distilling qualities; *Sesame*: white seeded, strong stemmed, multi-capsular with long capsules and large seeded lines, EC1123368 - EC 1123417/USA; *Linseed*: Wild species and germplasms with very high linoleic acid, high oil content, large seeded, early maturing and wilt resistant; *Fruit crops*: 57 improved varieties in fruit crops like almond, walnut, sweet cherry, plum, apple, grapes, quince and gooseberry were imported from Uzbekistan (EC1117584 - EC 1117641); *Dragon fruit varieties*: Big Red, Connie Mayer, Dark Star, Edger, Haleys Comet, Hawaiian Red, Makisupa, Maria Roza, Natural Mystic, Peruvian White, Purple Haze, Sugar Dragon, TLM White, Townsend Pink, Zamorano, S8 Sugar, Physical Graffiti, Godzila 26, George, ISIS Gold, Delight, Double Colour, Vietnam Red, Vietnam White, Da Hong, Chameleon, ISIS Yellow, Gautemelon Red, Israel Yellow, Malaysian

Red, Royal Red, Ruby Red, Siam Red, Thai Yellow, Orange, Palora, Pink Flesh, Taiwan Pink, Taiwan Red, Vietnam Giant (EC 1098376-416/ Philippines); *Brinjal*: Rootstocks resistant to bacterial wilt and fusarium wilt (EC 1099160-EC 1099163/Taiwan); *Pumpkin*: Globular to flattened fruit with dark orange flesh (EC 1098421-EC 1098425/Taiwan); *Gladiolus*: Species *Gladiolus dalenii* --drought tolerant (EC 1099553/ South Africa), species *Gladiolus virescens*, *G. carinatus* and *G. tristis* having fragrant flowers (EC 1099555-59/South Africa).

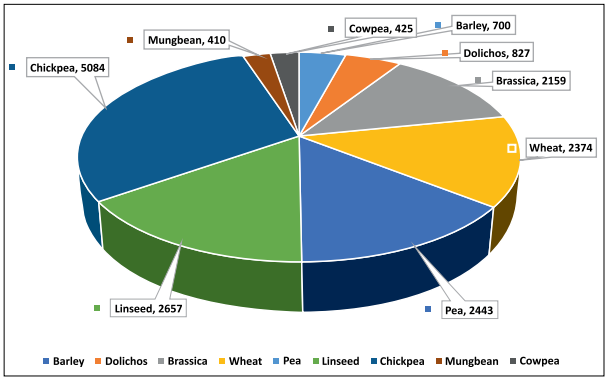
Besides this, 43 samples of fruit crops were exported to Uzbekistan [Apple (11), Pear (4), Plum (5), Peach (6), Apricot (6), Almond (4), Walnut (3) and Sweet cherry (4)] under collaborative research project.

PGR Policy: Ninth Governing Body (GB9) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was organized and hosted by India from 19-24 September, 2022 at New Delhi. Shri Narendra Singh Tomar, Hon'ble Minister of Agriculture, Government of India, inaugurated the 9th Session of Governing Body of the ITPGRFA and addressed the delegates. More than 400 delegates from nearly 150 member-countries assembled during the six-day long GB9.

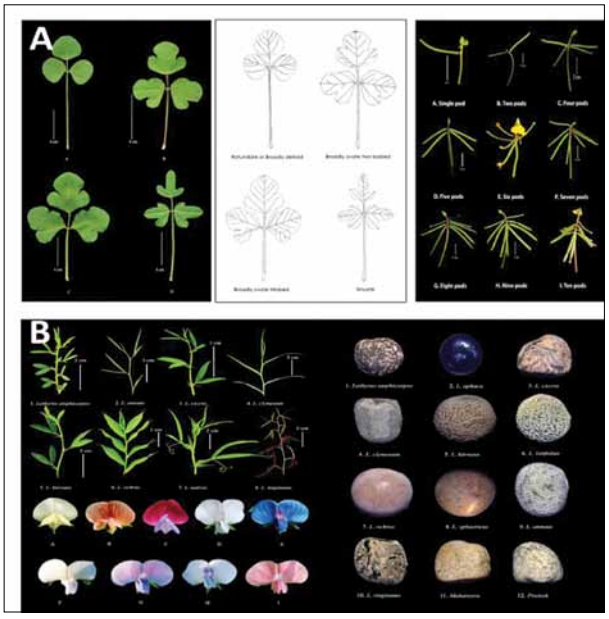
Shri Narendra Singh Tomar, Hon'ble Minister of Agriculture, Government of India inaugurating GB9 of ITPGRFA, in the presence of Shri Manoj Ahuja, Secretary, Department of Agriculture & Farmers Welfare, GoI. Dr Himanshu Pathak, Secretary, DARE & DG, ICAR; Ms Yasmina El-Bahloul, Chairperson of GB9 Bureau and Mr Kent Nnadozie, Secretary, ITPGRFA.

Indian delegation led the deliberation on various agenda items and GB9 re-establishes an "Ad Hoc Open-ended Working Group to Enhance the Functioning of the MLS". India was elected as the Co-Chair and will lead the process along with Australia. India (as a member of contact group to finalize resolution) pushed for focus on communities, farmer-conservers and women as "Guardians of Crop Diversity" to recognize their role in conservation and continued availability of crop diversity and GB9 adopted the resolution. Text of the treaty was also translated in hindi.

Germplasm characterization/evaluation: A total of 17,079 accessions of different crop plants were characterized during the reporting period for various traits. Mega characterization of chickpea germplasm (5,084 acc.), wheat germplasm (2,374 acc.) and linseed (2,700 acc.) germplasm and evaluation of Barley core set for terminal heat stress tolerance (678 acc.) was carried out. Core sets were developed in mungbean (400 acc.) and cowpea (425 acc). Phenotypic descriptors and



Accessions characterized for various agromorphological traits



Phenotypic descriptors and taxonomic delineation of *Vigna* and *Lathyrus* sp.

taxonomic delineation was done in *Vigna stipulacea* for 44 descriptors and genus *Lathyrus* for 26 descriptors. Two varieties, one each, of quinoa (Him Shakti) and buckwheat (Him Phaphra) were developed.

Plant quarantine: A total of 1,33,673 imported samples were processed for quarantine clearance. The 2,526 samples were found infested/infected with different pests. Of which, 326 samples were rejected due to fungal pathogens of quarantine importance. Important interceptions included– fungi (*Peronospora manshurica* and *Tilletia barclayana*); insects (*Bruchus dentipus, Callosobruchus rhodesienus* and *C. subinnotatus*), nematodes (*Aphenechoides besseyi, Pratylenchus penetrans, Meloidogyne* spp.). Four viruses were intercepted which have not been reported from India. Five noxious weeds (*Avena sterilis, Bromus secalinus, Echinochloa crus-pavonis, Ipomoea plebeia, Polygonum lapathifolium*) were intercepted not reported so far from India.

A total number of 3,287 samples of paddy were given mandatory hot water treatment. A total of 2,326 vegetative propagules were also given prophylactic

pesticidal dip treatment. A total of 70,882 seed samples were subjected to fumigation with aluminium phosphide (Phosphine @ 2 g per m^3 for 72 hr)/ethylene dichloride and carbon tetrachloride @ 320 mg/l for 48 hr. Rice samples infected with nematodes (331) were salvaged by hot water treatment. The rooted samples of apple infected with nematodes were salvaged by root-dip treatment of 0.25 % formalin for 10 min. A total of 337 imported samples of *Capsicum* spp. and *Solanum lycopersicum* were given prophylactic trisodium orthophosphate (10%). A total of 46 post-entry quarantine inspections were carried out for imported consignments at indentor's site. A total of 2,754 samples were processed for export issuing 8 Phytosanitary Certificates.

A Plant Quarantine Database and two Web-based applications (PGR Map and PGR Clim) were developed by ICAR-NBPGR. Once the procedure is completed, the same will be linked to the already operational web-application of Germplasm Exchange unit.

PGR Map was launched for public use on 16 August 2021 by Hon'ble Minister for Agriculture, Shri Narendra Singh Tomar.

PGR Clim was launched on 2 August 2021 during the 45th NBPGR Foundation Day by Prof. Paul Gepts, University of California, Davis.

DNA Fingerprinting

Plants: During the period under report, 96 samples of agri-horticultural crops were DNA profiled from different public and private sector organizations. The crops which were DNA profiled included Blackgram, Chickpea, Chilli, Cotton, Fababean, Greengram, Mustard, Oats, Paddy, Pea, Pearl millet, Pigeonpea, Sesame, Sorghum, Soybean, Sunflower, Taramira, Walnut and Wheat. Currently, National Genomic Resource Repository has 10,513 samples belonging to 46 species.

Microbes: To maintain the authenticity of biopesticides and to check the spurious and substandard products, the molecular identification and DNA fingerprint are mandatory requirements for registration of microbes as biopesticides. ICAR-NBAIM has been recognized as the nodal agency for developing DNA fingerprints of microbial cultures to be registered as biopesticides. More than 487 samples from more than 127 companies and biopesticide units working under CAUs/SAUs/State Departments have been processed for generation of fingerprint and accurate identification. The samples mainly contained *Verticillium lecanii* (now renamed as *Lecanicillium lecanii*), *V. chlamydosporium*, *Paecilomyces lilacinus* (renamed as *Purpureocillium lilacinum*), *Metarhizium anisopliae*, *Trichoderma harzianum*, *T. asperallum*, *Beauveria bassiana*, *Pseudomonas fluorescens*, *Bacillus amyloliquefaciens, B. subtilis*, *B. thuringiensis*, etc.

Insects: Molecular characterization and DNA barcoding was done for 50 agriculturally important insects.

Plant germplasm registration: A total of 277 proposals complete in all respect were considered for registration of the 443 proposals received. Finally, 230 proposals belonging to 104 species were approved for registration. Rice with low phytic acid (0.83 g/100 g) and high zinc content in grain (59.1 mg/kg); Maize resistant to turcicum blight; Wheat with high hectoliter (weight 80.4 kg/hl) and superior grain appearance; Barley with high beta glucan (7.5% dwb) and high protein (13.2%); Cotton with high ginning outturn percentage (43.9%); Cauliflower resistant to black-rot disease, carries single dominant resistant gene; Wild Bean highly resistant to bruchid; Tuberose with double flower type compactly arranged on short spike, more number of flowers open at a time (7.10) and resistant to root-knot nematode; Mango with polyembryony, tolerant to salt and regular bearing.

Seed Health Testing for Pest-free Conservation

A total of 12,612 indigenous samples were processed for pest-free conservation and 2,869 samples were subjected to X-ray radiography. A total of 514 samples were infested with insect-pests; 602 samples were infected with different fungi; 280 samples of rice seeds were infected with nematode. Of the total infested/infected, 45 samples were rejected due to *Tilletia carries* in wheat, *Tilletia barclayana* in rice and *Peronospora manshurica* in soybean.

Summary of trait specific germplasm registered During 2021-22 with current status

Crop group	Germplasm registered during 1st Nov. 2021 to 30th Sep. 2022	Present status
Cereals and pseudocereals	82	698
Millets	28	129
Fibre and forages	3	125
Grain legumes	29	199
Vegetables	31	132
Oilseeds	17	244
Commercial crops	00	114
MAP, spices and masticatory	20	127
Fruits and nuts	10	61
Tubers	08	54
Ornamentals	02	85
Narcotics	00	8
Agro-forestry	00	8
Grand total	230	1,984

Trait-specific germplasm registered during 2021-2022

Crop	National identity	INGR No.	Novel unique features
Banana (*Musa* spp.)	IC250498	22057	Resistant to *Fusarium oxysporum* f. sp. *cubense* (Foc) race 1 (VCG 0124).
	IC250650	22058	Resistant to Double type flower compactly arranged on short spike. More number of flowers open at a time (7.10). Resistant to root-knot nematode and *Fusarium oxysporum* f. sp. *cubense* (Foc) race 1 (VCG 0124).
	IC250462	22059	Resistant to *Fusarium oxysporum* f. sp. *cubense* (Foc) race 1 (VCG 0124).
	IC251061	22060	*Fusarium oxysporum* f. sp. *cubense* (Foc) race 1 (VCG 0124).
	IC250503	22061	*Fusarium oxysporum* f. sp. *cubense* (Foc) race 1 (VCG 0124). Resistant to *Pratylenchus coffeae*.
Barley (*Hordeum vulgare*)	IC640685	21125	Resistant to all the pathotypes of leaf and stripe rust at seedling stage. Possesses seedling resistance against all the pathotypes of black rust except for race 117-6 (shows moderately resistant response). Adult plant resistant to yellow rust with ACI less than 10. Adult plant resistance to leaf rust (highest score=0) and stem rust (highest score=5 MS).
	IC640686	21202	Seedling resistance against all races of leaf and stripe rust. Seedling resistant to moderately resistant response against all races of stem rust (except for race 11, showing moderately susceptible reaction). Adult plant resistance to yellow rust (average coefficient of infection (ACI) = 0 and highest score = 0 during 2018-19 and ACI less than 10, i.e. 8.6 during 2019-20). Also, adult plant resistance to leaf rust (HS=5S) and stem rust (HS=5S).
	IC0641987	21203	Combination of high beta glucan (7.5% dwb) and high protein (13.2%).
	IC0641988	21204	Low grain beta glucan (3.8%) and higher grain protein content (13%).
	IC0641990	21205	Low grain beta glucan content (3.88%) and desirable thousand grain weight (45 g).
	IC0641991	21206	Huskless genotype with high thousand grain (43.5 g) weight, in combination of bold grain percentage (63.2%) and protein content (14.7%).
	IC0641992	21207	Huskless resistant for stripe rust at APR and for new pathotypes 6S0 and 7S0 at SRT and also having starch content.
	IC0641989	22013	High hectoliter weight (66.7 kg/hl) coupled with higher protein content 13.0% (dwb) and bold grains (>2.5 mm size).
	IC645765	22074	High bold grain proportion in six rowed hulless barley as indicated with higher 1000 grain weight and bold grains percentage (76.7%).
	IC645770	22075	Hulless barley with combination of high grain beta glucan (7.0%) and protein (16.6%) content.
Barnyard millet (*Echinochloa esculenta*)	IC643966	22034	Glumeless florets and seeds.
	IC640691	21127	Highly resistant to grain smut disease.

Crop	National identity	INGR No.	Novel unique features
Basil (*Ocimum basilicum*)	IC643989	22053	Unique dark purple leaf colour. Maximum essential oil content (0.28%). Maximum eugenol content (60%),β-caryophyllene (14%) and β-elemene content (14%).
	IC643990	22054	Light green new leaf margin with club type purple coloured inflorescence. Maximum essential oil content (0.50%) in herbage. Maximum Linalool (32.13%), β-elemene (2.53%) and Germacrene D (3.32%) content.
Beetroot, Chukandar (*Beta vulgaris* var. bengalensis)	IC0632944	22086	Delayed bolting habit by 16-33 days favours 1-2 more number of cutting (s) during year round sowing; and have faster plant growth, i.e. 15.4% higher biomass production per cutting during round-the-year cultivation. Heat tolerance: Produces luxurious plant growth by tolerating high temperature, i.e. average temperature maxima of 39-43°C during April to June. Wide adaptability: VRPLK 2 produces higher marketable biomass yield, i.e. 136-887 q/ha during round the year monthly sowing which is 56-147% higher than standard check variety because of delayed bolting habit, faster plant growth and heat tolerance.
Ber *(Ziziphus mauritiana)*	IC0625596	21241	Small proportion of stone (7%). Excellent blend of TSS of 17-18 (ºB) acidity (0.35 %) and Vitamin C (51.2 mg/100 g). Superior in term of taste and fruit weight (23 g) compared to stone less landrace (INGR No. 19100) which gives gumminess feeling after eating of fruit and also have smaller fruits (1-2 g).
Black zedoary/Black turmeric (*Curcuma caesia*)	IC640709	21159	Rhizome essential oil content on fresh weight basis is more than 0.8%.
Bottle gourd (*Lagenaria siceraria*)	IC0635410	21145	Resistant to gummy stem blight. Short cylindrical fruit.
	IC0635411	21146	Resistant to gummy stem blight. Medium cylindrical fruit.
	IC0635413	21147	Resistant to powdery mildew. Elongated straight.
	IC0635412	21148	Resistant to gummy stem blight. Round shaped fruit.
	IC0635414	21215	Resistant to powdery mildew, elongated straight with stripes.
Brahmi (*Bacopa monnieri*)	IC0642012	21235	Maximum total Bacosides and Bacoside-A content. API quality parameters (Maximum alcohol soluble extractive and water-soluble extractive). Maximum pedicel length.
	IC0642013	21236	Curved/Twisty top leaf of stolon. Maximum basal leaf area. Rich in bacopaside.
	IC0642014	21237	Exceptionally whitish (Light purple) flower colour with purple branch colour. Maximum Jujubogenin content. Maximum Bacopaside C content.
	IC0642015	21238	Maximum number of leaves (760.83). Minimum leaf size (0.47-0.48 cm^2).
	IC0642016	21239	Morphotype having light green leaf colour. Purplish white flower colour. Low chlorophyll content (0.74-1.07 mg/ g).
Brinjal (*Solanum melongena*)	IC640704	21153	Resistant to bacterial-wilt disease caused by *Ralstonia solanacearum*. Fruit is medium in size, oblong in shape and purple in colour; average no. of fruits/plant is 7.0 with fruit weight of 76.25 g. Fruit yield of the variety is 16.0 t/ha during dry season of *rabi* under Andaman Island conditions; suitable for growing in rainfed conditions of tropical islands.
Broccoli (*Brassica oleracea* var. italica)	IC632628	21214	Purple heading early tropical type broccoli which produce seeds in Northern plains during winter season. In head, buds are fine to medium fine and buds and their stalks are intense purple therefore rich in anthocyanin (30.0 mg/100 g fw). Average marketable head weight ranges from 650-810 g and marketable yield is 27.0 t/ha.
Carissa *(Carissa carandas)*	IC0642018	21242	Multiple flowering/fruiting in a year (Sadabahar).
Carrot (*Daucus carota* subsp. *sativus*)	IC0623130 and IC0642961	22088	VRCAR 252 is a petalod-CMS line of black carrot with better heterotic potential for root yield and uniformity. The roots of VRCAR 252 are excellent source of plant derived anthocyanins (278 mg/100 g FW) & phenolics (323 mg GAE/100 g FW); having better anthocyanin yield potential (67 kg/ ha); and greater antioxidative ability (FRAP value of 47 µmol TE/g FW),

Crop	National identity	INGR No.	Novel unique features
			i.e. 28-times higher than red/orange/yellow carrots. VRCAR 252 and its maintainer are ideally synchronous in flowering/pollination activities which facilitate proper pollination and maximum seed set in CMS line.
Castor (*Ricinus communis*)	IC638880	21157	Resistance to leafhopper (*Empoasca flavescens*).Resistance to thrips (*Scirtothrips dorsalis*).
	IC0642011	21230	Dwarf pistillate line with condensed internodes, convergent branching, cup shaped leaves. Loose spike. Resistant to *Fusarium* wilt and leafhopper
Cauliflower (*Brassica oleracea* var. *botrytis*)	IC0642000	21217	Resistant to black rot disease (*Xanthomonas campestris* pv. *campestris* race 1). Carries single dominant resistant gene.
	IC0642001	21218	PC 1 is a new genotype of Purple Sicilian type (an intermediate type of cauliflower and broccoli) which produces attractive purple curds with light green stalks.The purple curding phenotype is governed by a single locus Pr with incomplete dominance but different from purple cauliflower. 'PC-1' curds are rich in anthocyanin (40.6±2.74 mg/100g FW) and mature in December month and produce seed profusely in sub-tropical condition.
	IC643987	22047	Highly resistant to downy mildew disease (c.o. *Hyaloperonospora parasitica*). Carry single dominant gene Ppa207 for downy mildew resistance. The resistant gene Ppa 207 was mapped in 4.8 cM linkage interval on linkage group 2 (C02) of cauliflower, flanked by the markers BoGMS0486 and BoGMS0900 at 3.6 and 1.2 cM, respectively.
Chickpea (*Cicer arietinum*)	EC267301	21137	Ascochyta blight resistance.
	IC248147	21138	Ascochyta blight resistance.
	IC640699	21141	Three seeds per pod in ~30% pods per plant with a mean of 2.62 seeds/ pod. Bushy plant architecture with semi erect canopy and basal branching pattern. Derived from wide hybridization of *Cicer arietinum* and *Cicer echinospermum* (donor). Seeds are yellow, angular in shape and small in size (13.7 g hundred seed weight).
	IC640700	21142	Tolerance to post emergent herbicide Imazethapyr (1.5X @ 150g a.i./ ha) with > 85% of survival and seed setting. Minimum phenological shift in the crop growth with respect to the unsprayed control. Matures in 127-130 days with the unsprayed crop with <5% yield penalty.
	IC272450	21144	Heat tolerant.
Chilli (*Capsicum annuum)*	IC631915	21154	Stalklessness or non-persistent calyx in red ripened fruit of chilli. Erect bearing habit. High yield.
	IC631916	21155	Stalklessness or non-persistent calyx in red ripened fruit of chilli. Pendent bearing habit. High yield and resistant to chilli leaf curl complex.
	IC0642004	21219	Resistant to chilli veinal mottle virus disease. Good general combiner for yield and quality traits.
China aster (*Callistephus chinensis*)	IC0624508	21166	Flower colour (Red Purple group, 65D, Fan 2). Long flower stalk (47.67 cm). Long vase life (10.11 days).
Cotton (*Gossypium barbadense*)	IC0641999	21212	Cleistogamous flower. Prominent boll tip. Three locule bolls.
Cotton (*Gossypium hirsutum*)	IC0641997	21213	High ginning outturn percentage (43.9%).
	IC643975	22021	Lintless. Fuzzless.Trichomeless.
Cowpea (*Vigna unguiculata*)	EC762384	21222	Dense pubescence.
Cucumber (*Cucumis sativus*)	IC645771	22085	High carotenoid content (54.8 µg/g in mature fruits; 8.12 µg/g in tender fruits). Orange flesh colour.
Cumin (*Cuminum cyminum*)	IC640712	21167	Flowering primordia initiation in 30 days, days to flowering initiation is 40 days and genotypes matures in 100 days under normal condition.

Crop	National identity	INGR No.	Novel unique features
Finger millet (*Eleusine coracana*)	IC640692	21128	Resistant to foot-rot. Resistant to leaf blast, neck blast and finger blast. High harvest index and high grain yield.
	IC640693	21129	Broad resistance to finger blast. Broad resistance to neck blast.
	IC640697	21132	Neck blast resistance. Finger blast resistance.
	IC640698	21133	Neck blast resistance. Finger blast resistance.
	IC624599	21211	Early flowering maturity. Red grain and high yielding.
	IC644006	22022	Banded blight resistance.
	IC0644004	22023	Finger blast resistance.
	IC644005	22030	Neck blast resistance.
	IC618375	22032	Bold white grains (3.14 g). Longer finger length (12.27 cm). Multi-fingers ear head (10.13 cm).
	IC643979	22033	Longer finger length (10.7 cm).
	IC640694	22096	Early maturity (100 days). White grain.
Foxtail millet (*Setaria italica*)	IC643959	22076	Early duration with high grain yield (1897 kg/ha). Multiple disease resistance. Thick and compact inflorescence.
French bean (*Phaseolus vulgaris*)	IC0360831	21136	Resistant to BCMV disease.
Ginger (*Zingiber zerumbet*)	IC640711	21165	High essential oil. Average rhizome essential oil was found to be 0.75% on fresh weight basis.
Groundnut (*Arachis hypogaea*)	IC640705	21156	Small size dark green leaves. Leaves remain green up to harvest. Resistant to stem-rot, late leaf spot and rust.
	IC0642010	21229	Novel source for high hundred kernel weight (85.36 g).
Horse gram (*Macrotyloma uniflorum*)	IC643992	22079	Very early maturing (84 days). Semi-dwarf. Synchronous maturity.
Indian mustard (*Brassica juncea*)	IC640708	21158	Heat tolerant at juvenile stage under field conditions.
	IC640707	21228	White rust resistance.
	IC643977	22050	Resistant against *Sclerotinia sclerotiorum*. Half yellow and half brown (mottle seed colour). High male and female fertility.
	IC643976	22051	Resistant against *Sclerotinia sclerotiorum*. Yellow seed colour. Stable somatic hybrid.
	IC645773	22089	High temperature tolerance at seedling stage coupled with high seed and oil yield.
	IC645757	22097	Resistant against *Alternaria brassicae*. High yield potential on the Somatic hybrid H1. Short height and duration than the H1.
	IC645758	22098	Resistant for *Alternaria brassicae*. High yield potential on the Somatic hybrid H2. Short height and duration than the H2.
	IC645774	22099	High temperature tolerance at seedling stage. Moisture stress tolerance.
Jamun (*Syzygium cumini*)	IC0635379	21168	Seedless.
Lentil (*Lens culinaris*)	IC241473	21223	Multiflowering and multipodding germplasm with fasciated stem.
	EC499760	22036	Bold seed (7.1-7.83 g).
	IC241532	22037	Early flowering (51 days) and maturity (93 days).
Little millet (*Panicum sumatrense*)	IC640696	21131	Early flowering (47 days), early maturity (71 days).
	IC0483093	22077	Early flowering (50-52 days) and early maturity (83-85 days) with grain and fodder yield advantage.

Crop	National identity	INGR No.	Novel unique features
Maize (*Zea mays*)	IC640688	21208	Resistant to Turcicum-leaf blight (TLB) (Disease mean score 2.6 on the scale of 1-9).
	IC640689	21209	Resistant to Turcicum-leaf blight (Disease mean score 2.5 on the scale of 1-9).
	IC640690	21210	Resistant to Turcicum-leaf blight (Disease mean score 2.4 on the scale of 1-9).
	IC0644007	22014	Nutritionally enriched. Developed through marker-assisted selection. Enhanced beta-carotene (7.46 ppm), lysine and tryptophan (0.298% and 0.080%).
	IC0644008	22015	Nutritionally enriched. Developed through marker-assisted selection. Enhanced beta-carotene (7.40 ppm) lysine and tryptophan (0.333% and 0.068%).
	IC0644009	22016	Nutritionally enriched. Developed through marker-assisted selection. Enhanced beta-carotene (6.89 ppm), lysine and tryptophan (0.383% and 0.074%).
	IC0644010	22017	Nutritionally enriched. Developed through marker-assisted selection. Enhanced beta-carotene (6.12 ppm), lysine and tryptophan (0.336% and 0.079%).
	IC0643993	22018	Liguleless. Early maturating in the genetic background of elite inbred V 407 (female parent of Vivek Maize Hybrid 53 and CMVL 55).
	IC0643994	22019	V 602 is broadly broad genetic background of elite inbred V 407 (female parent of Vivek Maize Hybrid 53 and CMVL 55).
	IC643958	22020	Tolerant to high density planting. Flint and orange colored kernel. Medium maturity.
	IC640687	21126	Resistant to turcicum-leaf blight (Disease mean score 2.6 on the scale of 1-9).
Mango (*Mangifera indica*)	IC0594046	22094	Polyembryony. Salt tolerant. Regular bearing .
Mung bean (*Vigna radiata*)	IC641993	22046	Highly resistant to yellow mosaic disease caused by mungbean yellow mosaic India virus.
	EC0398949	21224	This genotype maintains a cool canopy even under moisture stress.
Narkachur (*Curcuma zedoaria*)	IC640710	21160	Rhizome essential oil content on fresh weight basis is more than 0.6%.
Nightshades (*Solanum khasianum*)	IC0633577	21161	White colour berries.
	IC0633426	21162	High solasodine content in the fruits more than 1.30%. The range of solasodine content in the fruits 1.19%- 1.37%.
	IC0633547	21163	Thornless leaves and stem.
	IC0633432	21164	Red colour berries at ripening stage
Noni (*Morinda citrifolia*)	IC0590895	22055	Big fruit (140-160 g), high pulp recovery. Vigorous plant (3-4 m) and year round yielder.
	IC0590905	22093	Small fruit (55-60 g), high yield due to more number of fruits. Dwarf stature (1.7-2.5 m) and year-round yielder.
Nutmeg (*Myristica fragrans*)	IC645756	22092	Monoecious, fruits borne in clusters of 2 to 7. High yielding.
Oil palm (*Elaeis guineensis*)	IC0610001	21231	Short stature (28.9 cm). high FFB (243.91 kg). More number of bunches (13) Dura genotype.
	IC0610001	21232	Low annual height increment (25.25 cm). High FFB (211.33 kg). Tenera genotype.
	IC0610051	21233	High yielding (261.71 kg). More number of bunches (16.66). Dura genotype.

Crop	National identity	INGR No.	Novel unique features
Onion (*Allium cepa*)	IC645764	22082	Waterlogging tolerant.
	IC645763	22083	Drought tolerant.
	IC645760 & IC645761	22084	Long day/intermediate day length onion line with cytoplasmic male sterility (CMS).
Pea (*Pisium sativum* subsp. *hortense*)	IC640701	21139	Single flower per peduncle on all the floral nodes.
Pea (*Pisium sativum)*	IC636671	21140	Extra early flowering. Early maturity. Yellow cotyledon.
	IC0642003	21221	Resistant and to powdery mildew disease.
	EC414478	21225	Unique seed morphotype with extended funiculus
	IC640782	21227	Resistance to rust and powdery mildew.
	IC640783	22043	Moderately resistant to rust.
	IC640781	22044	Extra early flowering and maturity. Green seeded. Resistance to powdery mildew and rust.
	EC564816	22045	Semi-leafless field pea genotype with intact/extended funiculus.
	IC0642307	22087	Extra early genotype of vegetable pea (*Pisum sativum* var. *hortense*). Synchronous maturity, thus suitable for single picking or mechanical harvesting and multiple cropping.
Pearl millet (*Pennisetum glaucum*)	IC643982	22035	High Fe content (84 ppm). High Zn content (50 ppm).
Potato (*Solanum tuberosum*)	IC640713	21169	Interspecific somatic hybrid-derived clone MSH/14-7 [cv. Kufri Garima × Bulk pollen of somatic hybrids (*S. tuberosum* + *S. pinnatisectum*)] with wider genetic base. High yield combined with moderate resistance to late blight under field condition.
	IC640717	21173	Interspecific somatic hybrid-derived potato hybrid [cv. Kufri Garima × somatic hybrid 'Crd10' (*S. tuberosum* + *S. cardiophyllum*] with wider genetic base. Yellow tuber flesh colour hybrid with high carotenoid content.
	IC640718	21174	High nitrogen use efficiency. High yield under low nitrogen (50 kg N/ha) supply under field conditions and suitable for low input agriculture.
	IC644002	22062	MSP/15-26 is an elite cultivated potato clone (2n=4x=48). Possessing high carotenoids in flesh. Yellow flesh colour with red vascular ring.
	IC644003	22063	MSP/15-51 is an elite cultivated potato clone (2n=4x; 48). High ascorbic acid in flesh. Distinct red purple flesh.
Potato (*Solanum cardiophyllum)*	IC640714	21170	Highly resistant to late blight disease. Suitable for protoplast fusion and somatic hybrid development.
Potato (*Solanum stoloniferum)*	IC640716	21172	Highly resistant to late blight disease.
Potato (*Solanum pinnatisectum)*	IC640715	21171	Highly resistant to late blight disease. Suitable for protoplast fusion and somatic hybrid development.
Radish (*Raphanus raphanistrum* subsp. *sativus*)	IC0642005 and IC0642006	21220	Cytoplasmic male sterile (CMS) line having lyrate leaf shape and blunt root (almost cylindrical root shape). Good combiner and higher heterosis for yield (12.5-33.6%), root length (6.5-32.4%) and root weight (17.2-30.0%) during winter season.
	IC643967	22048	High tolerance to irrigation water salinity (ECiw 8-10 dS/m) and soil sodicity (pH 8.5).
Rambutan (*Nephelium lappaceum*)	IC0642756	22095	Yellow colour fruit. More number of fruits per bunch (15-20 fruits/bunch). Medium fruit size.

Crop	National identity	INGR No.	Novel unique features
Rice (*Oryza sativa*)	IC639795	21112	Tolerance to sheath blight and low soil P tolerance.
	IC640647	21113	Low glycemic index content (45.72%).
	IC640651	21114	Highly drought tolerant line. Resistant to blast disease.
	IC637523	21115	Resistance against leaf folder.
	IC575321	21116	Tolerant to salinity stress. Tolerant to stagnant flooding (both fresh and saline water). Has high anaerobic germination potential.
	IC640648	21117	Tolerant to salinity at vegetative stage (12 dS/m). Tolerant to salinity at reproductive stage (8 dS/m).
	IC640649	21118	Possess micronutrient Zn – 22.6 ppm and Fe – 3.36 ppm in polished rice grain.
	IC0641981	21176	Dual donor for resistance to brown planthopper (BPH) and whitebacked planthopper (WBPH) in rice. Possessed bph4, Bph 9, Bph 17 and Bph 32 genes for BPH resistance; and wbph 9 and wbph 10 genes for WBPH resistance.
	IC640650	21177	Aromatic early maturing rice elite line for rainfed uplands. Long slender grains. Very early duration (85-90 days).
	IC560851	21178	Drought tolerant high yielding elite line for rainfed direct seeded upland conditions. Early maturing (95-100 days).
	IC0640883	21179	Drought tolerant. Phosphorus starvation tolerant. Weed competitiveness.
	IC0643999	22001	*sd*1 gene
	IC426273	22064	Possess grain Zn >24 ppm content in polished rice. Possess unique aroma and grain type-aromatic short grain (ASG).
	IC643971	22065	Higher grain yield than Nagina 22 (Tolerant parent) and KMR 3 (Susceptible parent) under high temperature stress (> 5 ºC) and ambient temperature. Heat-tolerant in terms of stable yield across varied temperature locations (Based on stability variance and rankings). Heat tolerant in terms of increased coefficient of non-photochemical quenching (qN) trait under high temperature stress.
	IC0642852	22066	Low phytic acid in grain (0.83g/100g). High zinc content in grain (59.1 mg/kg).
	IC645776	22067	Stable grain yield under low nitrogen (N) and 50% of the recommended N (N-50) inputs across tested field locations under AICRP. High nitrogen-use efficiency (NUE), physiological efficiency (PE) and recovery efficiency (RE) under N-50 input. High grain yield than Vardhan.
Rice bean (*Vigna umbellata*)	IC251442	21226	Photo-period insensitive. Thermo-period insensitive.
	IC251442	22041	Highly resistant to *Callosobruchus maculatus.*
	IC009634	22042	Very bold seeds, weighing 37.44 g of 100-seed weight.
Safflower (*Carthamus tinctorius*)	IC643960	22052	Tolerance to safflower aphid (*Uroleucon compositae*).
Sesame (*Sesamum indicum*)	IC643978	22090	High lignin content (sesamin 61.2 ug/ml; sesamol 15.1 ug/ml). High oil content (52.9% w/w). Tolerance to charcoal rot (*Macrophomina phaseolina*).
Sorghum (*Sorghum bicolor)*	IC640695	21130	Grain mold resistant
	IC640645	21134	Total soluble sugar (9.14% TSS)
	IC640646	21135	Resistant to anthracnose
	IC0288432	22024	More leaf stem ratio (0.32). Low HCN content (40.9%).
	IC643757	22025	Longer leaves (86.5 cm). More plant height (276 cm). More number of leaves per plant (12.9).

Crop	National identity	INGR No.	Novel unique features
	IC643980	22026	High fresh stalk yield. High biomass. Sorghum x maize cross derivative.
	IC643968	22027	High oil content (4.49%). Hard seed with bigger germ size.
	IC643969	22028	High oil content (4.17%). Very bold seed with medium hardness and small germ size.
	IC643970	22029	High *in vitro* true digestibility of dry-matter (TDDM/IVDMD), Organic matter digestibility (OMD) and Metabolizable energy content (ME). Low acid detergent fibre (ADF) and Acid detergent lignin (ADL) content.
	IC643981	22031	Higher brix and total sugars (14.3%), early maturing. Early maturing (116 days). Early flowering (80 days).
	IC643961	22078	Early maturing (110.3 days) yellow grained sorghum. Dwarf yellow grained sorghum.
Soybean (*Glycine max*)	EC34372	22091	Anthracnose resistance. Early maturing. Out of six genes tested for early maturity and photoperiod response (E1, E2, E3, E4, E9 and E10), four had shown rare alleles (e2, e3, e4 and e9).
Sunflower (*Helianthus annuus*)	IC628063	21175	Resistant to powdery mildew (PDS<10%).
Taro (*Homalomena aromatica*)	IC0642007	21234	High rhizome essential oil yield of 1.20% on dry weight basis.
Tomato (*Solanum lycopersicum*)	IC640702	21149	Broad spectrum resistance to Tomato Leaf Curl Virus (ToLCV). Ty-3 gene carrying line with uniform ripening fruits. It has greater combining ability.
	IC0637249	21150	Broad spectrum resistance to Tomato Leaf Curl Virus (ToLCV). Ty-3 gene carrying tomato elite line with green fruit shoulder. It has greater combining ability
	IC0637252	21151	Broad spectrum resistance to Tomato Leaf Curl Virus (ToLCV). Ty-2 and Ty-3 gene pyramided line. Uniform ripening fruits.
	IC640703	21152	Dwarf plant
	IC0637253	21216	Broad spectrum resistance to Tomato leaf curl virus (ToL CV). Ty-2 and Ty-3 gene pyramided line. Plum shaped fruits with distinctive thick green shoulder.
	IC644011	22049	Root Knot Nematode resistance. *Alternaria solani* resistance. ToLCV resistance and heat tolerant.
Tuberose (*Polianthes tuberosa*)	IC0633777	22056	Double type flower compactly arranged on short spike. More number of flowers open at a time (7.10). Resistant to root-knot nematode.
Turmeric (*Curcuma longa*)	IC0642017	21240	High leaf essential oil yielding variety with essential oil yield more than 1.2%.
Wheat (*Triticum aestivum*)	IC640653	21119	Resistant to all pathotypes of yellow rust in seedling stage. Resistant to all pathotypes of brown rust in seedling stage except for race 77-5. Resistant to yellow rust and brown rust at adult plant stage.
	IC640670	21120	Soft grain (low grain hardness index). Low sedimentation value (38.8 ml).
	IC640671	21121	Soft grain (low grain hardness index). High nutritional value [Zn (47.2 ppm), Fe (41.2 ppm) and protein (13.01%)].
	IC640672	21122	Very high grain zinc (48.3 ppm) with high grain yield (56.4 q/ha)]
	IC640673	21123	Very high grain iron (44.0 ppm) and zinc content (45.7 ppm).
	IC640683	21124	High sedimentation value (73-75 ml) for greater gluten strength.
	IC640652	21180	Novel leaf rust resistance gene Lr80. Confers broad spectrum leaf rust resistance.
	IC0638606	21181	Resistant to all pathotypes of Yellow (Stripe) Rust. Possessing rust resistance genes Yr15 and Sr25/Lr19.
	IC640679	21182	High hectoliter weight.

Crop	National identity	INGR No.	Novel unique features
	IC640680	21183	High grain zinc concentration (57 mg/kg).
	IC640681	21184	High hectoliter (Weight 80.4 kg/hl). Superior grain appearance.
	IC640682	21185	High grain iron concentration (48.1 ppm).
	IC640684	21186	High sedimentation value (73-75 ml) for greater gluten strength.
	IC290156	21187	Resistant to stripe rust pathotypes 46S119 and 47S103 due to presence of favourable alleles for resistance against these prominent races and thus, showed less disease severity presence of 11 novel significant QTLs confers resistance against stripe rust. Associated with a candidate gene TraesCS6D02G384800, which functions as leucine-rich repeat receptor-like protein kinases (LRR).
	IC321906	21188	Terminal heat tolerance. Presence of QTLs with favourable alleles for 3 different traits, viz. grain yield, grain filling rate and biomass.
	IC0641982	21189	High level of Fe (43.8 ppm), Zn (48.6 ppm) and protein content (14.3%).
	IC0641983	21190	Resistant to stem, leaf and stripe rusts. Resistant to Karnal bunt. High yielding.
	IC0641984	21191	Resistant to stem, leaf and stripe rusts. Resistant to flag smut. High yielding.
	IC0641985	21192	Heat stress tolerant genotype with lower grain yield reduction under stress. Higher grain number under heat stress. Higher grain weight under heat stress.
	IC0641986	21193	Resistant to black and brown rusts. Resistant to Karnal bunt and flag smut.
	IC640669	21194	Glu-D1 double null with lowest sedimentation volume in the background of PBW 502 and suitable for biscuit making.
	IC640675	21195	Highly resistant to wheat blast and brown rust. Resistant to black and yellow rust diseases of wheat.
	IC640676	21196	Consist of one adult plant minor stem rust resistance gene (APR), Sr2 which has pleiotropic effect on leaf rust (*Lr27*) and stripe rust (*Yr30*) resistance. Contains two major stem rust (*Sr24* & *Sr36*), one leaf rust (*Lr24*) and one powdery mildew (*Pm6*) resistance genes. Resistant to the prevailing stem rust, leaf rust and powdery mildew pathotypes.
	IC640654 and IC640655	21197	New cytoplasmic genetic male sterile line in DBW 16 background with CMS source MTSA 2A along with maintainer (B) line.
	IC640656 and IC640657	21198	New cytoplasmic genetic male sterile line in DBW 16 background with CMS source Chuan 13A.
	IC640666	21199	Triple gene dwarf genotype possessing bold seeds and longer spikes.
	IC640667	21200	Highly tolerant to water stress conditions of warmer areas. Low SSI. Low yield reduction under stress.
	IC631397	21201	High grain hardiness index (important quality parameter).
	IC0640658 and IC0640659	22002	New cytoplasmic genetic male sterile line in DBW 17 background with CMS source Chuan 13A.
	IC0640660 and IC0640661	22003	New cytoplasmic genetic male sterile line in CBW 38 background with CMS source MTSA 2A.
	IC0640662 and C0640663	22004	New cytoplasmic genetic male sterile line in DBW 55 background with CMS source Chuan 13A.
	IC0640664 and IC0640665	22005	New cytoplasmic genetic male sterile line in UP 2338 background with CMS source MTSA 2A.

Crop	National identity	INGR No.	Novel unique features
	IC0640668	22006	Highly tolerant to water stress conditions of warmer areas. Low SSI. Low yield reduction under stress.
	IC0296727	22007	High level of grain zinc content (51.3 ppm). Protein content (13.8%).
	IC0279317	22008	Physio-biochemical traits. Yield and yield traits. Heat stress indices.
	IC0336816	22009	Heat tolerance nature.
	IC0212176	22010	Gigas plant with reduced number of tillers (69 tillers/m row) and long spike (12 cm).
	IC0643956	22011	High grain zinc concentration (48.6 ppm).
	IC0643957	22012	Low hardness index (32) (Soft endosperm). Low SDS-sedimentation value (40.5 ml).
	IC640677	22068	Consists of one adult plant minor stem rust resistance gene (APR), Sr2 which has pleiotropic effect on leaf rust (Lr27) and stripe rust (Yr30) resistance. Contains two major stem rust (Sr24 and Sr36), one leaf rust (Lr24) and one powdery mildew (Pm6) resistance genes. Resistant to the prevailing stem rust, leaf rust and powdery mildew pathotypes.
	IC645768	22069	Contains three major stem rust (Sr24, Sr26 and Sr36), one leaf rust (Lr24) and one powdery mildew (Pm6) resistance genes. Resistant to the prevailing stem rust, leaf rust and powdery mildew pathotypes of India.
	IC335971	22070	Heat tolerant.
	IC645762	22071	Heat tolerant.
	IC645769	22072	Contains three major stem rust (Sr24, Sr26 & Sr36), one leaf rust (Lr24) and one powdery mildew (Pm6) resistance genes resistant to the prevailing stem rust, leaf rust and powdery mildew pathotypes of India.
	ICIC73591	22073	Resistance to leaf rust.
Wild bean (*Vigna vexillata)*	IC259504	22038	Highly resistant to bruchid.
	IC248326	22039	Resistant against *Callosobruchus maculatus*
Wild bean (*Vigna stipulacea)*	IC331436	22040	Early flowering (20 days after sowing). Early maturity (49 days after sowing).
	IC553521	22080	High protein content (24.6%).
	IC553564	22081	Long peduncle length (63 cm).
Wild vigna (*Vigna glabrescens*)	IC251372	21143	Photo-period insensitive. Thermo-period insensitive.

Microbial Genetic Resources

The total number of microbial holdings in the National Agriculturally Important Microbial Culture Collection (NAIMCC) is 7,789 AIMs including 4,297 fungi, 3,134 bacteria and actinomycetes and 358 cyanobacteria. During 2021-22, 589 microbes including 167 fungi, 411 bacteria including actinomycetes and 11 cyanobacteria were accessioned from different states of the country. During the year 2021-22, 17 new microbial species, viz. *Anoxybacillus flavithermus* subsp. *yunnanesis, Bacillus cytotoxicus, Bradyrhizobium subterraneum, Chryseobacterium daecheongense, Glutamicibacter nicotianae, Lapillicoccus jejuensis, Lysinibacillus macrolides, Mesorhizobium helmanticense, Novosphingobium pokkalii, Orrelladios coreae, Paenibacillus kribbensis, Aseprgillus tabacinus, Bipolaris sorghicola, Fusarium thapsinum, Fusarium fujikuroi, Lichtheimia hyalospora* and cyanobacteria *Themosynechococcus elongates* were accessioned under general deposit category. Besides deposit of microorganisms under General Deposit, NAIMCC also offers a Safe Deposit service for AIMs. In 2021-22 a total of 26 microbes were accessioned under safe deposition and about ₹7,04,000.00 revenue was generated. About 72 cultures which included 15 fungi, 55 bacteria and 2 cyanobacteria were sold to different stakeholders (academia and companies) earning revenue of ₹2,91,600.00. The NAIMCC also provides soft protection to elite microorganisms possessing unique or novel traits/properties under Microbial Germplasm Registration Service.

Insect resources

During the period, 17,971 insects were collected

and curated. A total of 2,16,093 dead insect specimens are being maintained at the National Insect Repository of ICAR-NBAIR. Apart from museum specimens, it maintains (*ex-situ* conservation) 136 live insects (107 parasitoids, 15 predators, 13 pest insects and one detritivore). These insects are being mass multiplied and supplied to different stakeholders throughout the year. It is one of the largest live insect repository in Asia. The Bureau also has rich repository of entomopathogenic organisms such as *Bacillus thuringiensis* **(**304**),** *Pseudomonas* spp**.** (28), *Trichoderma* spp (24), *Paecilomyces lilacinus* (6), *Beauveria bassiana* **(**64**),** *Metarhizium anisopliae* (33), entomopathogenic nematodes (124), baculoviruses (8) and others including culturable gut bacteria (135).

One new genera and 10 new species of insects were described. Eight taxa were recorded for the first time from India and there were 32 new regional distribution records within India, 62 new host plant/new host insect records and molecular characterization and DNA barcoding has been done for 50 agriculturally important insects.

New species of parasitoids: Two new species of parasitoid wasps, *Pambolus* (Phaenodus) *infuscatus* (Braconidae: Pambolinae) and *Paroplitis khajjiarensis*) (Braconidae: Microgastrinae) were described and illustrated from Himachal Pradesh, India. A key to the Oriental species of *Pambolus* and an updated key to the world species of *Paroplitis* were provided. Additionally, *Centistes* (*Centistes*) *cuspidatus* (Braconidae: Euphorinae) was reported for the first time from the Indian geographical boundaries.

Horticulture Genetic Resources

Germplasm Collected

Indigenious sources: During the year, a total of 3,346 accessions of horticultural crops comprising 182 fruits [Mango (11), citrus (10), guava (10), bael (10), tamarind (4), rose apple (24), jamun (8), dragon fruit (23), jack fruit (4), papaya (6), banana (11), muskmelon (3), longan (52), grape (6)], plantation crops (15); 1,595 vegetables [Potato (44), okra (5), brinjal (481), garden pea (450), french bean (86), onion (42), carrot (3), radish (7), ridge gourd (133), cucumber (202), bottle gourd (3), ash gourd (23), drumstick (92), curry leaf (10), pumpkin (8) and summer squash (6)]; 112 tuber crops [Cassava (48), sweet potato (13), taro (29), elephant foot yam (5), greater yam (3), wild yam (2), lesser yam (1), Colocasia (1), Chinese potato (1) and other minor crops (9)]; 108 spices [Black pepper (29), Zingiberacious spices (41), nutmeg (5), cinnamon (5), clove (1) and Garcinia (27)], 1075 flowers and medicinal plants [Gladiolus (12), *Gymnema sylvestris* (10), brahmi (10), betel vine (1), rose (35), chrysanthemum (09), orchids (83), anthurium (13), tuberose (05), gerbera (24), marigold (16), lilium (11), dahlia (05), specialty flowers (31), ornamental fillers and florist greens (51), medicinal and aromatic plants (759)] and 215 mushrooms (175 collections were identified up to genus level and 30 specimens up to species level) were collected from different sources.

Exotic sources: A total of 59 germplasm accessions comprising tomato (35), chilli (40), brinjal and bell pepper (5 each) were collected from exotic sources.

Characterization and Identification of Germplasm

A total of 26 germplasm accessions showing unique traits in different horticultural crops were registered as novel genetic stock with ICAR-NBPGR, New Delhi as detailed hereunder:

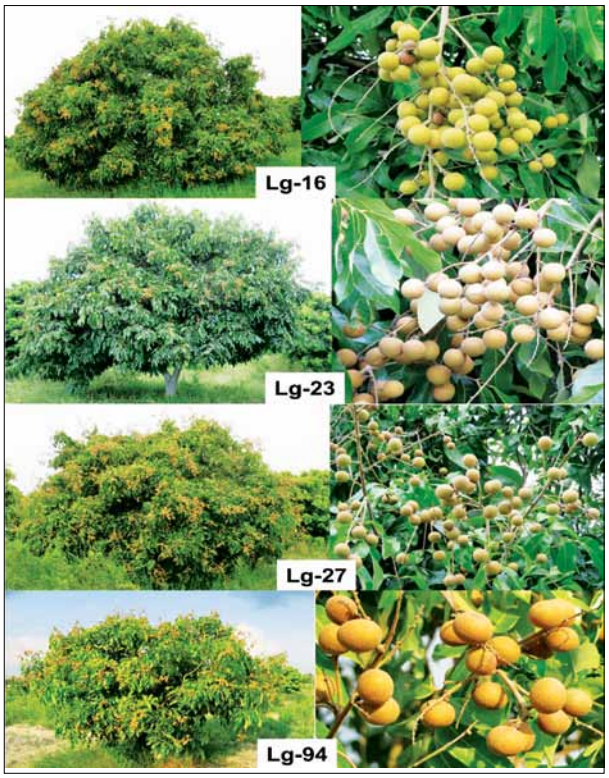
Crop	INGR Number	Unique features	
Banana	22057	NRCB Acc. No. 0045- Borchampa, AAB genome, Resistant to *Fusarium oxysporum* f. sp. *cubense* (Foc) Race 1.	
	22059	NRCB Acc. No. 009 -Borjahaji, AAA genome, Resistant to Focrace 1.	
	22061	NRCB Acc. No. 0050 -Karthobiumtham, ABB genome, Resistant to Focrace 1 and root-lesion nematode, *Pratylenc-hus coffeae.*	
	22058	NRCB Acc. No 0197 –Poovan, AAB genome, Resistant to Focrace 1.	
	22060	NRCB Acc. No. 0608 – Williams, AAA genome Resistant to Focrace 1.	
Ram-butan	22095	Yellow colour fruit. More number of fruits per bunch (15-20 fruits/ bunch) of medium fruit size.	
Oil palm	INGR 21231	Short stature, high FFB yield with more number of bunches, *dura* group.	
	INGR 21232	Low annual height increment with high FFB yield, *tenera* group.	

Crop	INGR Number	Unique features	
	INGR 21233	High yielding with more number of bunches, dura	
Pea	INGR 21139	Unique line (VRP Sel-17) bearing single flower on all the peduncles registered as unique germplasm.	
Radish	INGR 21220	VRRAD-12, a CMS line of radish with lyrate leaf.	
Tomato	INGR 21149	VRT-2-2-3-1 line - unique germplasm for ToLCV resistance .	
	INGR 21150	RT-12-1-3-2- unique germplasm for tomato leaf curl virus (ToLCV) resistance.	
	INGR 21151	VRT 6-1-4- unique germplasm for ToLCV resistance.	
	INGR 22049	H-88-78-1- heat tolerance, root knot nematode and ToLCV resistance.	
Bottle gourd	INGR 21215	Resistant to powdery mildew, elongated straight with stripes.	
Potato	INGR 21075	Late blight resistance.	
Potato	INGR 21074	Late blight resistance,	
Onion	INGR 22083	Accession 1656 for drought tolerance.	
	INGR 22082	Accession 1666 for excess soil moisture stress tolerance.	
Chrysanthemum	INGR 21108	DFR C-1 Attractive, double floret, pink flowers.	
	INGR 21109	DFR C-2- Profuse flowering (166 flowers/ plant), creamy white, semi double with ligulate florets.	
	INGR 21110	DFR C-3- Single floret with attractive yellow flowers and ligulate florets. Plant bears 163-169 number of flowers per plant.	
Tuberose (*Polianthes tuberosa*)	INGR 22056	Double floret compactly arranged on short spike. More number of flowers open at a time (7.1). Resistant to root knot nematode (*Meloidogyne incognita*).	
Betel vine	INGR 21076	Rolling leaves	

Promising Germplasm Accessions Identified

Longan: Five genotypes of longan promising for fruit size (8.1 – 8.5 g/fruit) namely Lg-16, Lg-23, Lg-27, Lg-62 and Lg-94 were identified. Of these, maximum pulp content (76.47%) was recorded in Lg-62 while other had pulp content lower than the average (71.9%). Four identified genotypes namely, Lg-16, Lg-23, Lg-27

and Lg-62 had high TSS content (20.1°B) more than the average while only Lg-94 recorded TSS lower than the average.



Fruiting in identified genotypes of longan

Oil palm: An oil palm cross progeny number 483 (599NATP × 33D) promising for more oil to bunch ratio (21.37%) was identified.

Orchids: A long stalked *Paphiopedilum insigne* germplasm NOAC- 235) was identified.

In addition, a floriferous germplasm of *Dendrobium chrysanthum* (NRCOP-21054) was identified.

Basil: A total of four promising basil germplasm accessions were identified having different quality traits as described hereunder.

DLB-7: Lemon basil (*Ocimum* × *africanum*) has broad ovate leaf and rich in citral A (40.59%) and citral B (48.59%) content.

DLB-10: Lemon basil (*Ocimum* × *africanum*) has maximum leaf size and herbage yield (298 q/ha).

DOGr-3: Clove basil (*Ocimum gratissimum*) has broad ovate leaf and rich in eugenol (75.45%) and caryophyllene (11.7%) content.

DIB-1: Basil (*Ocimum basilicum*) has upward leaf folding with severe puckering and rich in methyl eugenol content (30%).

DOGr-2: Clove basil (*Ocimum gratissimum*) has narrow ovate leaf and rich in β-copaene (20.48%) and α-Bergamotene (15.23%) contents.

Mushroom: A total of 175 fungal mushroom accessions were identified up to genus level and 30 up to species level. Of these collections, some of interesting specimens are *Amanita concentrica*, *Amanita caeserea*, *Amanita onusta*, *Lactarius deliciosus*, *Cysclocybe aegerita*, *Scleroderma citrinum*, *Ramaria aurea*, *Chlorophyllum molybdites* etc. Culturing of 8 specimens namely *Coprinus comatus*, *Pleurotus* sp., *Cordyceps militaris*, *Isaria cicadae*, *Ramaria* sp., Ganoderma, *Flammulina* sp. and *Herecium* sp. was done. All the specimens had been deposited in herbarium at ICAR-Directorate of Mushroom Research, Solan (HP).

Mushroom specimens collected by ICAR-DMR, Solan

Quick response (QR) coded gene bank established: A QR coded gene bank exclusively for wild genetic resources of banana was established at ICAR-National Research Centre for Banana, Tiruchirappalli. This is the first of its kind in India which conserves the genetic diversity of *Musa* spp. (11 no.) and for identifying resistant sources to various biotic and abiotic stresses in banana.

Livestock Genetic Resources

Registration of new indigenous livestock breeds: Ten new breeds of indigenous livestock species were registered. These breeds are Kathani cattle (Maharashtra), Sanchori cattle (Rajasthan) and Masilum cattle (Meghalaya); Purnathadi buffalo (Maharashtra); Sojat goat (Rajasthan), Karauli goat (Rajasthan) and Gujari goat (Rajasthan); Banda pig (Jharkhand), Manipuri black pig (Manipur) and Wak Chambil (Meghalaya). Total number of registered indigenous breeds has reached to 212, including 53 for cattle, 20 for buffalo, 37 for goat, 44 for sheep, 7 for horses and ponies, 9 for camel, 13 for pig, 3 for donkey, 3 for dog, 1 for yak, 19 for chicken, 2 for duck and 1 for geese.

Newly registered breeds

Purnathadi buffalo (Accession No.: INDIA_BUFFALO_1100_PURNATHADI_01020)**:** Milk yield ranges from 353 to 1533 kg per lactation. Milk fat percentage ranges from 6.5 to 11.5.

Kathani cattle Accession No.: INDIA_CATTLE_1100_KATHANI_03051

Sanchori cattle (Accession No.: INDIA_CATTLE_1700_SANCHORI_03052)**:** Average daily milk yield is about 9 kg with 2,769 kg milk in a lactation.

Masilum cattle Accession No.: INDIA_CATTLE_1300_MASILUM_ 03053

Sojat goat (Accession No.: INDIA_ GOAT_ 1700_ SOJAT_ 06035)**:** Average adult weight is about 60 kg in males. Average milk yield in female is about 1 kg per day.

Karauli goat (Accession No.: INDIA_ GOAT_1700_ KARAULI_06036)**:** Average adult weight in males is about 52.0 kg. Average daily milk yield is 1.530 kg.

Gujari goat (Accession No.: INDIA_GOAT_1700_GUJARI_06037)**:** Average adult weight is about 69.0 kg in males and 58.0 kg in females. Average daily milk yield is 1.616 kg.

Banda pig (Accession No.: INDIA_PIG_2500_BANDA_09011)**:** Average adult body weight is 28.0 kg in male and 27.0 kg in females. Litter size ranges from 4 to 7.

Manipuri Black pig (Accession No.: INDIA_PIG_1200_MANIPURIBLACK_09012)**:** Adult body weight averages about 96.0 kg in males and 93.0 kg in females. Litter size ranges from 6 to 11 at birth.

Wak Chambil pig (Accession No.: INDIA_ PIG_1300_ WAKCHAMBIL_ 09013): Average adult body weight is 32.0 kg in males. Litter size at birth ranges from 4 to 11.










Ex situ Conservation of AnGR

Germplasm repository at National Gene Bank is being strengthened by preserving diversified form of animal germplasm (semen, somatic cells and DNA) of indigenous livestock and poultry. A total of 44,860 semen doses of 17 native livestock breeds, including nine of cattle (Red Sindhi, Badri, Red Kandhari, Nimari, Deoni, Gaolao, Bhijarpuri, Ghumsari, Khariar) and 8 of goat breeds (Ganjam, Jamnapari, Beetal, Berari, Osmanabadi, Sirohi, Sangamneri and Barbari) were cryopreserved in the National Gene Bank. Also, 1,020 somatic cell vials of 7 native breeds- Purnea, Mewati, Hariana and Shweta Kapila of cattle, Konkan Kanyal of goat, Doom and Purnea of pig were added for cryopreservation. Presently, National Gene Bank has repository of 61 native breeds/populations of livestock and poultry in form of Semen, and 28 in form of Somatic cells.

Pig

An improved crossbred pig variety 'Rani', developed by using Hampshire (male) and Ghoongroo (female) pigs, has completed the eighth generation of inter-se mating. The generation-wise genetic performance has revealed stability in the performance of the developed variety over the generations. The litter size at birth and weaning were recorded as 9.91±0.40 and 8.92±0.32, respectively for the 9th generation. Large scale propagation of the developed variety coupled with use of scientific package of practices and artificial insemination has ensured its rapid propagation as well as sustainable livelihood among the farmers.


Rani pig at farmer's field

Horse

Characterization and recognition of Bhimthadi horse: The Bhimthadi breed was developed in Pune district in 17th and 18th centuries during the Maratha rule. The best Bhimthadi horses were found in the valleys of the Bhima and Nira rivers in the Pune district. These horses proved excellent for Shivaji's forces in fighting the Mughal army in the hilly terrains of Western Maharashtra.The breed has been shown to be critically endangered to near extinction in the literature.


Bhimthadi breed of horse

In order to characterize and recognize the breed, a panel discussion with the horse breeders of Pune and Baramati was organised and the origin, history, distribution and characteristics of the Bhimthadi horses were discussed. Basic socio-economic status of the horse breeders along with recording of morphometric traits was carried out for 120 Bhimthadi animals. It was

Mission towards zero non-descript AnGR of India

The Mission towards Zero Non-descript AnGR of India is to document native livestock and poultry genetic resources and identifying potential breeds to reduce the percentage of non-descript AnGR population in the country. Earlier the mission was launched on 11th August, 2021 by Dr T Mohapatra, Secretary, DARE and Director General, ICAR. The launch workshop was attended by 215 participants consisting of Directors/senior officers of State Animal Husbandry Departments all over India, scientists, researchers from SAU/SVUs, ICAR Animal Science institutes, Bureaus and, NGOs/Societies and farmers. Bureau has also organized Interface Meet with 12 states–Chhattisgarh, Jharkhand, Maharashtra, Rajasthan, Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, West Bengal, Himachal Pradesh, Bihar, Telangana and one Union Territory (Ladakh) in a year. The interface meets were attended by the officers of State Animal Husbandry Departments, SAU/SVUs, ICAR Animal Science Institutes, NGOs/Societies.
The Bureau has initiated state specific AnGR documentation projects in 22 states in collaboration with SAHD, KVKs, SAUs/SVUs. Bureau scientists have initiated survey in 18 states/UT after the Mission was launched. Total 22 new populations of native livestock and poultry have been identified after launch of Mission, which are being characterized in their respective breeding tracts falling in various states. These populations are Malluck sheep, Malra goat and Changkhi dog of Ladakh (UT); Balona buffalo and native buffalo of Gadchiroli and Chandrapur districts and Khamgaon cattle of Maharashtra; Native buffalo of Jharkhand; native cattle of Meghalaya; native cattle, mithun and chicken of Mizoram; Lahuri goat and Dang sheep of Madhya Pradesh; Battisi goat of Uttar Pradesh; Kombai dog of Tamil Nadu; Malkangiri pony, Burudi pig, Gola pig of Odisha; Native yak of Sikkim; Mahi cattle and Native goat (Kari-piri) populations of Rajasthan; Eki dog of Arunachal Pradesh; and Kotdhar goat of Himachal Pradesh.

observed that the Bhimthadi horses are mostly reared by tribal people which are still nomadic. These tribal people do rear good number of sheep and goat along with the Bhimthadi horses. The predominant colour is chestnut, however other colours such as white, piebald, skewbald, etc. are also acceptable. Among the facial markings, star, strip, snip, blaze is common. These animals are relatively smaller in size with average wither height of about 128 cm, body length of 127 cm and heart girth of 139 cm, and are of very docile nature.

Characterization

Manipuri cattle: Manipuri cattle is mainly distributed in Imphal West, Imphal East, Thoubal, Bishnupur, Senapati and Churachandpur districts of Manipur. Manipur cattle are small and sturdy with compact body. Age at first calving was observed to be 34.09 (± 0.17) months, while inter-calving period was about 12 months. Average daily milk yield was observed to be 2.415 (±0.033) l. Manipuri cattle are known for their exceptional draft capabilities, and are in high demand in neighbouring states.

Alambadi cattle of Tamil Nadu: Alambadi animals are medium in size with body length 118.66±1.90 cm, height at withers 114.53±1.15 cm, heart girth 147.22±1.96 cm and paunch girth 153.19±2.37 cm. Milk yield is very less and ranges from 1.0 to 1.5 l per day. Mitochondrial diversity analysis of Alambadi cattle revealed that Alambadi cattle are distinct from Hallikar and clustering in same node with Bargur cattle breed.

Native goat and sheep of Chambal region of Madhya Pradesh: Two new populations–Lahuri goat and Dang sheep were characterized.

Lahuri goat: Highly homogenous goat, distributed in Sabalgarh area of Morena and Vijaipur, Birpur of Sheopur districts. The goats are adapted for grazing in Dang-ravine areas of Chambal.

Dang sheep: Native sheep population is distributed in Bhind, Morena and Sheopur districts, of Chambal division. Population is more than 10 thousand animals. Reared for meat purpose.

Native yak of Sikkim: Sikkim yak is distributed in North, East and West districts of Sikkim having maximum population in North Sikkim. Medium to large in size with moderate temperament. Coat colour is mostly black to dark brown with glossy sheen. Head and face combined forms triangular shape. White marking on forehead is quite common. Muzzle is comparatively smaller to the face. Neck is small with no dewlap. Flank, lower belly, and thigh regions are covered with long hair. Tail is small with long hair and set high.

Changkhi dog of Ladakh (UT): The mean of important biometric traits (N=100), viz. height at withers, height at base of the tail, body length, chest girth, paunch girth, head width, snout length, head length, neck length, neck girth, ear length, ear width tail length (in

cm) and body weight (kg) were 63.99±0.45, 61.85±0.54, 69.59±0.79, 71.98±70, 65.37±0.57, 10.14±0.18, 9.24±0.11, 17.52±0.22, 16.36±0.40, 51.30±0.42, 10.75±0.59, 9.79±0.71, 34.56±0.34 and 25.93±36 respectively. The age at sexual maturity in dogs ranges from 12-16 months. The age at first whelping is about 20 months.

Combai dog of Tamil Nadu: The animals have short coat. The colour of majority dogs was observed to be reddish brown to light brown with a black muzzle and nostrils. Important biometric traits, viz. height at withers, body length, chest girth, paunch girth and tail length (in cm) are 54.14±0.42, 52.62±0.38, 63.03±0.42, 48.64±0.60 and 32.41±0.27, respectively.

Haofa dog of Manipur: Haofa,'the dog of the Tangkhuls' is considered an indigenous hound dog of Manipur. It is medium to large in size and weighs between 15-25 kg. Body height at wither, body length,chest girth (in cm) are 57.9±1.82, 57.5±1.34 and 67.4±2.31, respectively.

Fish Genetic Resources

New records of fishes and shellfishes from the Indian waters: Freshwater fish species discovered were: *Amblycepsh molaii* sp. nov. (ZSI FF 9059, holotype, 51.5 mm SL), a catfish species from Kawlchaw river of Kaladan river drainage in Mizoram.

Pangasius icaria from Cauvery river basin in two locations- at Mettur dam, and in the upstream of Shivanasamudra falls, Chamarajanagar, Karnataka. *Tor sattalensis*, a new species under the mahseer genus *Tor,* from Sattal Lake, Uttarakhand in the Western Himalayan region of India.

Marine fish/shrimp species discovered were: *Eptatretus wadgensis* (Family Myxinidae, Genus: Eptatretus), a new hagfish, was collected from Wadge Bank area in Lakshadweep Sea at a depth of approximately 250-300 m. *Dussumieria modakandai* sp. nov. (NBFGR, holotype, 144.99 mm SL) discovered from Tamil Nadu coast. Eels, viz. *Ariosomaalbi maculatum* collected from Off Kanyakumari, Arabian Sea; *Ariosoma indicum* from Arabian Sea and Bay of Bengal, possibly having a continuous distribution along the Indian coast; *Ariosoma maurostigma* from Off Kerala, Arabian Sea and *Ariosoma melanospilos* from Colachel, Off Kanyakumari, southwest coast of India. The marine shrimp *Actinimenes koyas* (Decapoda: Palaemonidae) was collected from the coral atoll of Agatti Island, Lakshadweep, Arabian Sea.

Identified the new distributional ranges of fish and shellfish species, viz. *Garra annandalei* (Hora 1921), commonly known as Annandale garra or Tunga garra. This species was so far reported only from the eastern side of India and the present finding from the middle

Amblycepsh molaii sp. nov.

Pangasius icari

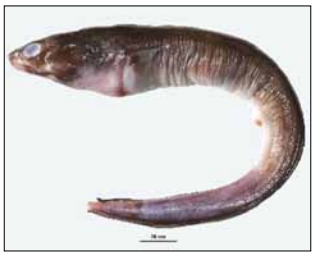
Tor sattalensis

Eptatretus wadgensis

Dussumieria modakandai sp. nov

Ariosoma melanospilos

stretch of river Tapti extend its range of distribution in west coast rivers of India. Hippolytid shrimp, *Lysmata hochi* (Baeza Anker 2008) and *Lysmata amboinensis* (De Man 1888) and palaemonid shrimp, *Palaemon ellatenuipes* (Dana 1852), and *P. rotumana* (Borradaile 1898) were recorded from the Lakshadweep Island, Arabian Sea. *Urocaridella antonbruunii* (Bruce 1967) was recorded from the bottom curve of the coral boulders in Gulf of Mannar and Agatti Islands. *Ariosoma dolichopterum* was recorded from Colachel, Off Kanyakumari, southwest coast of India, Indian Ocean. The Canary top Wrasse, *Halichoeresleu coxanthus* (Randall and Smith 1982), previously distributed from Maldives, Myanmar, Christmas Island (Australia), Thailand and Western Indonesia was recorded for the first time from Indian waters. Also observed a progressive change in fish diversity in Hooghly-Matlah estuary. For the first time, recorded catch of marine/deep



Ariosoma albimaculatum

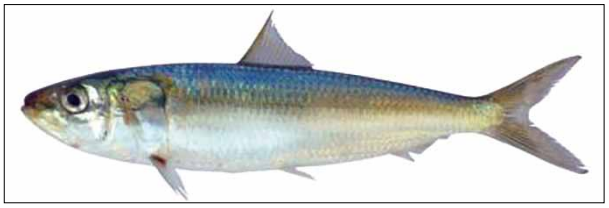
Ariosoma indicum

Ariosoma maurostigma

Actinimenes koyas

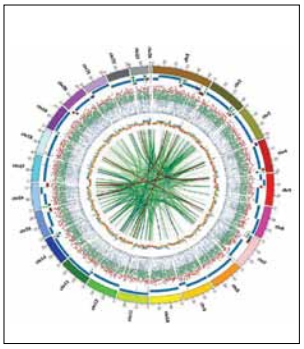
sea fish species like *Aluterus monoceros, Antennarius indicus, Ariomma indica, Diodon hystrix*, *Lobotes surinamensis*, *Nemipterus randalli, Priacanthus prolixus*, and *Seriolina nigrofasciata* in the estuary.

Characterization of whole genome assembly: Indian oil sardine, *Sardinella longiceps* Valenciennes, 1847 whole genome assembly is 1.077 Gb (31.86 Mb scaffold N50) in size with a repeat content of 22.84%. The estimated genome size is 1.118 Gb and the assembly coverage is 96.3%. The sequences were deposited to NCBI, GenBank.



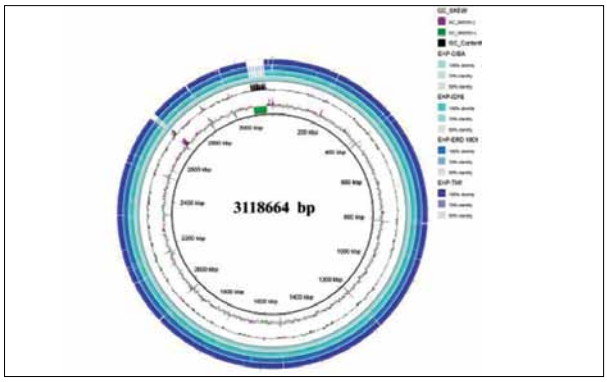
Sardinella longiceps

Flathead grey mullet, *Mugil cephalus* whole genome sequence was found to be of 644 Mb in length in 583 scaffolds with N50 of 28.32 Mb. The genome was predicted to be 96% complete with 27,269 protein-coding genes and 11.72% repetitive elements.



Circos plot depicting the 24 pseudochromosomes in *M. cephalus* assembly and their features. Track 1 (outermost) depicts 24 pseudochromosomes; track 2 depicts contig lengths; track 3 shows protein-coding genes; track 4 shows GC content; track 5 (innemost) depicts self synteny in the genome.

Shrimp microsporidian, *Enterocytozoon hepatopenaei* (EHP), is causative agent of disease Hepatopancreatic microsporidiasis (HPM) in farmed shrimp. The whole genome of EHP yielded a sequence size of 3.12 Mb (3118664 bp) in 22 contigs with a GC content of 26.36%, longest contig size 8,11,456 bp, N50 value 2,35,882 and N90 value of 1,51,450 bp. The Indian EHP whole genome shared 99.4% genome similarity with the Chinese isolate, 99.5% with Thailand isolate, and 98.8% with the Indonesian isolate. This study reported the whole genome of EHP from India for the first time.



Whole genome assembly of *Enterocytozoon hepatopenaei* (EHP)

Phenotypic variation among *Chitala chitala* populations from Indian rivers: *Chitala chitala* (Hamilton 1822) is an economically important food fish species occurring throughout Indian rivers, which also has ornamental value. The phenotypic variance was identified. The significant parameters differentiating specimens from different rivers were linked to dorsal fin origin, the base of the pectoral fin and the perpendicular point on the anal fin from the dorsal fin origin. Variation in the hydrodynamics of the rivers might be possibly affecting the fin kinematics and consequently leading to adaption seen as phenotypic variation. These phenotyping tools have great importance for the scientific management and conservation of species. The species exhibited significant phenotypic plasticity which explicitly indicates the presence of at-least seven different morphotypes of *C. chitala* in the subpopulations found in different rivers. Use of advanced variable molecular markers in combination with phenotyping tools is highly desirable in future, for documenting diversity in this species.

Development of fish cell lines: Developed cell lines from rainbow trout heart (RBT-H) and snow trout muscles (SRM-1). Both the cell lines were authenticated and deposited in ICAR-NBFGR National Repository of Fish Cell lines, with accession numbers NRFC075 (RBT-H) and NRFC079 (SRM-1), respectively.

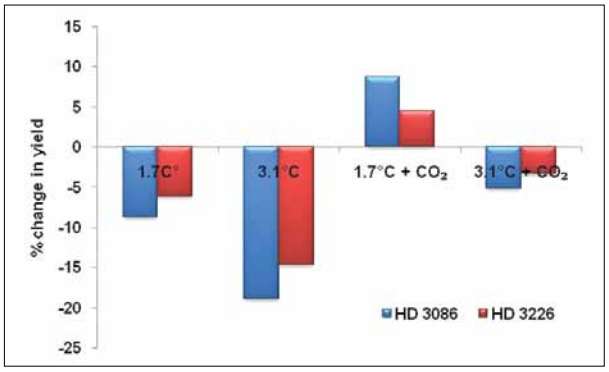
❑

6. Crop Management

Crop Production

Methane utilizing plant growth promoting bacterial formulation for mitigating methane emission from flooded rice: Liquid formulation of a consortium of methane utilizing bacteria (MUB) *Methylobacterium oryzae* MNL7 and *Paenibacillus polymyxa MaAL70* applied through seedling root dip technology and as spray formulation at maximum tillering and flowering stage in rice across three locations showed significant reduction in methane production by 5 to 25%.

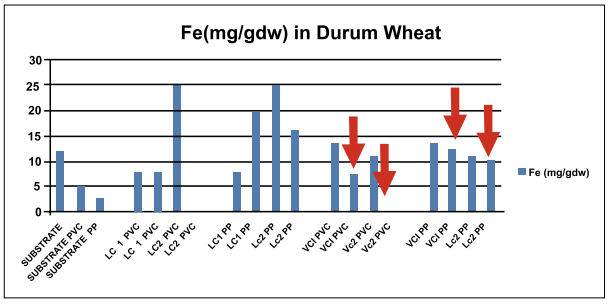
Elevated carbon dioxide (CO_2) alleviates significantly the growth and yield reduction, caused by elevated temperature and ozone respectively in wheat and rice: Yield reduction in wheat and rice respectively under elevated temperature and elevated ozone was compensated under the elevated CO_2 condition. Rise in temperature by 1.7°C with elevated CO_2 in fact showed an increase in grain yield across two wheat varieties. Elevated CO_2(ECO_2) with elevated O_3 (EO_3) alleviated the negative effect of ozone on grain yield which was further compensated under ECO_2 + EO_3 + 125% recommended dose of nitrogen (RDN) treatment and also improved the grain N content.



Change in yield in different wheat varieties in elevated CO_2 and temperature treatments

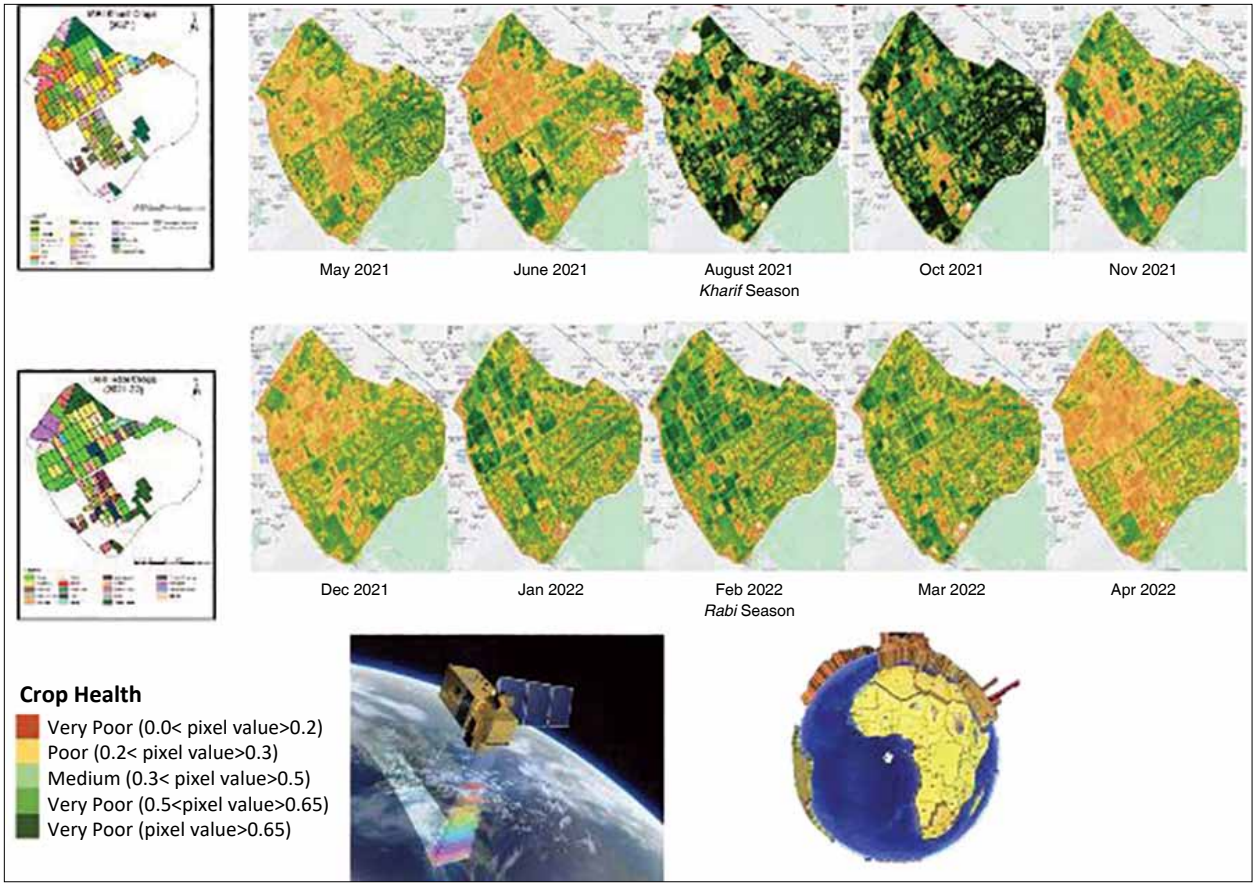
Microplastics in agri-inputs on soil-plant attributes: Durum and bread wheat were exposed to leaf compost (LC) and vermicompost (VC) enriched with polyvinyl chloride (PVC) and polypropylene (PP) and the response in terms of plant growth and nutrient availability and uptake was deciphered. Study clearly shows that microplastics in the farm inputs will alter the nutrient availability and uptake.

Generation of spatio-temporal crop environment and composite crop health indices from satellite remote sensing and dissemination through web Geoportal: Satellite based crop health indices such as Vegetation Condition Index, Temperature Condition Index, NDVI deviation, Evaporative Stress Index, etc. were developed for whole India on regular basis. These data products were uploaded on CREAMS and ICAR-KRISHI geoportal (http://geoportal.icar.gov.in: 8080/geoexplorer/composer/) on regular basis. Near real time crop condition monitoring was developed using google earth engine platform and moderate resolution satellite data. The framework was developed for IARI campus with details information collected at ground for crops and cropping system during 2021–22. Crop condition monitoring was done using different vegetation indices derived from moderate resolution satellite data and a Normalized Composite Index was developed for crop health monitoring. This framework is under test for upscale to large scale applications.



Effect of microplastics (PVC, PP) enrichment of farm inputs (leaf and vermicompost) on shoot Fe content of durum wheat (HD-4728)

Real time soil moisture-based irrigation scheduling of green pea: Real time soil moisture-based irrigation scheduling of green pea was conducted through field trials. The experiment was laid out in split-plot design with 4 irrigation treatments with controlled soil matric potentials (SMP) of I_1, -20 kPa; I_2, -30 kPa; I_3, -35 kPa and I_4, -40 kPa and 3 fertigation levels 120%, 100% and 80% of recommended dose of fertilizer (RDF kg/ha), i.e. 40 N, 60 P and 50 K in drip irrigated, plots and 3 replications. Higher green pea (pod) yield (17.9 t/ha) was observed in -30 kPa SMP threshold with 120% of recommended dose of fertilizer treatment whereas the average yield of green pea in India is 7–11 t/ha. Lower yield was observed in I_4 treatment with 80% RDF through fertigation. The low frequency of water application in I_4 treatment led to uneven distribution of moisture content which hampered the absorbance of water and nutrients by the root system. Statistical analysis of yield parameter showed that irrigation treatments and fertigation treatments effects were significant at 1% level with the CD value of 0.32. The depth of irrigation water applied through drip irrigation system was 163 mm (effective rainfall 26 mm and irrigation water applied 137 mm) whereas the depth of water applied in surface irrigation



A framework for satellite based near real time crop condition monitoring using google earth engine

was 304 mm. It was concluded that there was a water saving of 44–50% in real time soil moisture based irrigation schedule than the surface irrigation practice.

Post emergence herbicide for weed control in chickpea: The impact of Post herbicides available in different crops were assessed in chickpea at ICAR-IIPR, Kanpur, Uttar Pradesh and thereafter in AICRP on chickpea. Topramezone @20.6 ml a.i./ha at 14–21 DAS had higher weed control efficiency (up to 90%). It significantly controlled the dominant broad-leaved weeds: *Chenopodium album*, *Lepidium didymum*, *Spergula arvensis*, *Medicago polymorpha* and *Fumaria parviflora* Lam. compared to the other tested herbicides. Topramezone increased 15–20% chickpea seed yield than the recommended herbicide pendimethalin 1,000 g a.i/ha, quizalofop-p-ethyl 100 g a.i./ha. Hence, topramezone can be recommended as selective post-emergence herbicide in chickpea for managing broad-spectrum weeds and realizing higher productivity.

Agronomic bio-fortification in chickpea: Agronomic management strategies to improve grain yield and grain Zn concentration in chickpea through use of different Zn-application methods like soil, foliar and seed treatments which are simple, efficient and cost-effective for farmers were studied for two consecutive years (2020–21 and 2021–22). Foliar spray at 0.5% $ZnSO_4$ (sprayed at the pre-flowering and pod formation stage) is reported to have higher seed zinc content of 65 to 75 ppm and was 20 to 25% higher when compared to control. Therefore, foliar spray at 0.5% $ZnSO_4$ at pre-flowering and pod formation stage in chickpea is recommended to envisage higher yields with increased grain zinc content. The genotypes JG 16, GNG 2171, and IPC 10 62 were found to have increased response to soil application of Zn 38.2 % internal Zn use efficiency

Real time irrigation scheduling in green pea using Tensiometer

index (IUEIZn) higher over average value; while the genotypes, GNG469, Vijay and GNG 2171 exhibited higher IUEIZn (32.9%) over the mean value of all genotypes in response to foliar application.

Conservation agricultural practices: Conservation agricultural practices improved grain yield of all the *kharif* (rainy) crops (cluster bean, green gram, maize, pearl millet and sesame) compared to conventional tillage (CT). Permanent beds with residue recorded highest grain yield of *kharif* crops followed by zero tillage and CT. Permanent beds with residue increased system grain yield by 17.1 and 35.3% over zero tillage and conventional tillage, respectively. Cropping systems significantly influenced grain yield (2,835 kg/ha) and harvest index (34.4) of mustard and recorded significantly higher under maize-mustard cropping system. Significantly higher system grain yield was recorded under green gram-mustard cropping system (4,676 kg/ha).

Developing sugarcane based integrated farming system models for small farm holders of sub-tropical India: ICAR-IISR, Lucknow planned and executed the sugarcane based Integrated farming system with objective to develop integrated farming system models for small farm holders. The autumn sugarcane based integrated farming system as Sugarcane + Vegetables (Garlic, Fenugreek, Coriander, Tomato, Cauliflower, Spinach, Carrot, Faba bean, Onion, Brinjal, Green chilli, Cabbage, Pea, Soya, Sauf, Bottle guard, Okra, Cowpea, Cucurbit, Maize) + Horticultural crop (Karonda boundary plantation + Papaya + Banana) + Backyard poultry (Asheel, Nirbheek, Kadaknath, Quail) + Dairy unit (Sahiwal) + Fisheries (Rohu, Catla, Nain) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom fetched net income ₹4,48,202.5/ha and an additional income of ₹2,65,902.5/ha.The spring sugarcane based integrated farming system as Sugarcane + Vegetables (Bottle gourd, Sponge gourd, Tomato, Brinjal, Pumpkin, Onion, Maize Fenugreek, Pachoi, Chinese gobhi) + Horticultural crop (Banana, Karonda, Papaya) + Backyard poultry (Asheel, Nirbheek, Kadaknath, Quail) + Dairy unit (Sahiwal) + Fisheries (Rohu,Catla, Nain) + Vermicompost (*Eisenia fetida*) + Apiculture + Mushroom fetched net income of ₹4,30,370/ha and an additional income of ₹2,63,020/ha.

Crop Protection

Wireless smart trap for automated pest monitoring in cotton: To circumvent the limitations of the conventional pheromone trapping system, a wireless smart trap was developed at the ICAR-Central Institute for Cotton Research, Maharashtra for a real time pest monitoring. The CICR Wireless Smart Trap houses four individual pheromone septa in a modified delta trap system targeting the key lepidopterous pests of cotton, viz. *Pectinophora gossypiella,* [7,11-hexadecadienyl acetate]; *Spodoptera litura [*(Z,E)-9,11-Tetradecadienyl acetate]; *Helicoverpa armigera*, [Z-9-Hexadecenal] and *Earias vittella* [(E, E)-10, 12- hexadecadienyl]. The trap catch recorded as images and transmitted at

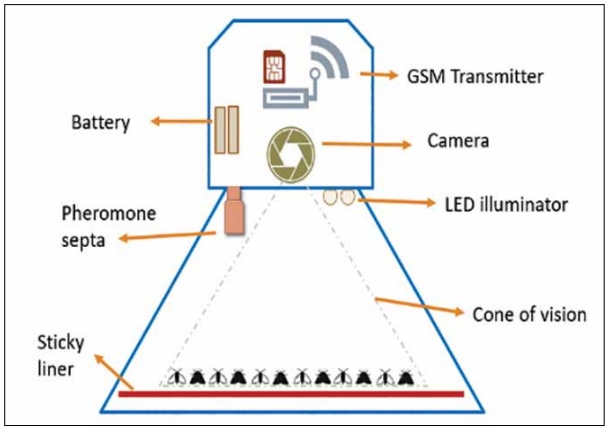
Productivity and profitability of different components of the cropping/farming system Integrated with sugarcane (autumn planted sugarcane)-2021-22

Cropping/Farming systems	Cost of production (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	Income from component crop/ enterprise (₹/ha) or enterprises /unit	B:C ratio
Sugarcane (Sole) CoPk 05191	166200	348500	182300	-	2.09
Sugarcane + Vegetables (including horti.crops) Throughout year	184800	408542.5	223742.5	41,442.5	2.21
Sugarcane + Vegetables (including horti.crops) Throughout year + Backyard poultry + Dairy unit	211650	519052.5	307402.5	83,660	2.45
Sugarcane + Vegetables Throughout year (including horti.crops) + Backyard poultry + Dairy unit + Fisheries + Vermicompost + Apiculture + Mushroom	222100	670302.5	448202.5	1,40,800	3.01
Additional income from no.4 S-IFS model-₹2,65,902/ha					

Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (spring planted sugarcane)-2021-22

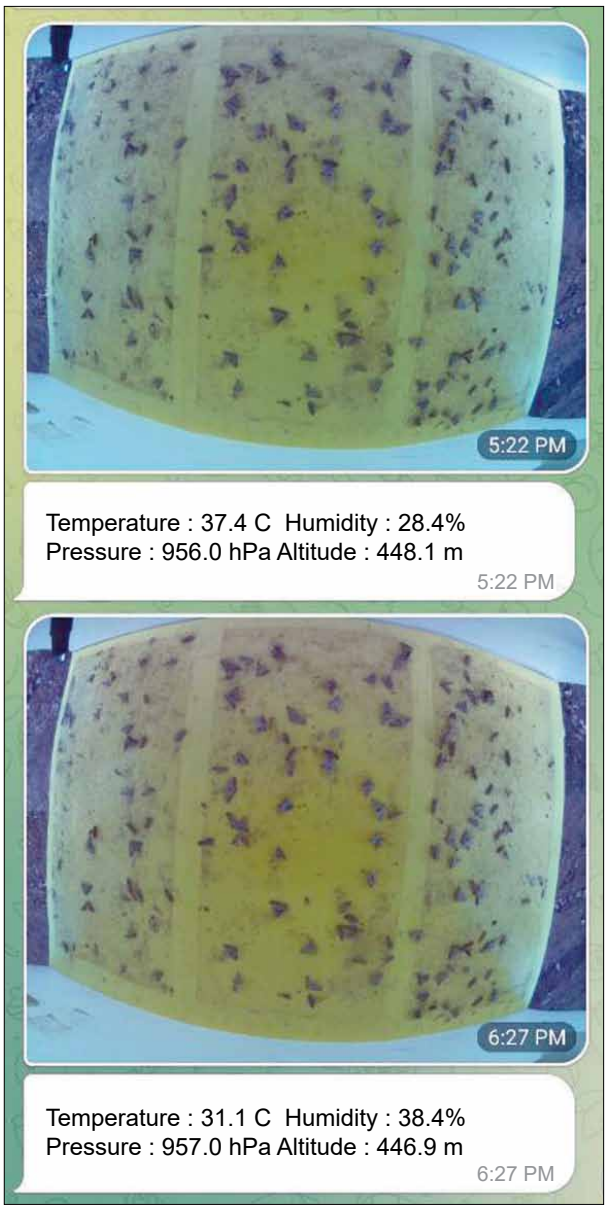
Cropping/Farming system	Cost of production (₹/ha)	Gross income (₹/ha)	Net income (₹/ha)	Income from component crop/ enterprise (₹/ha) or enterprises /unit	B:C ratio
Sugarcane (Sole) CoPk05191	168400	335750	167350	-	1.99
Sugarcane + Vegetables (including horti.crops) Throughout year	180900	401940	221040	53,690	2.22
Sugarcane + Vegetables (including horti.crops) Throughout year + Backyard poultry + Dairy unit	205900	495470	289570	68,530	2.40
Sugarcane + Vegetables Throughout year (including horti.crops) + Backyard poultry + Dairy unit + Fisheries + Vermicompost + Apiculture + Mushroom	216350	646720	430370	2,89,570	2.98
Additional income from no.4 S-IFS model-₹2,63,020/ha					

hourly intervals to a remote server with corresponding weather data.The system consists of a single board computer (Raspberry Pi Zero W); wide angle (150^0) camera module; BME 280 weather sensor and a GSM transmitter. The standalone system is powered by 10 W solar panel with a rechargeable NiCd battery. A control unit triggers the camera module at hourly intervals to record an image of trapped insects along with the data on temperature, relative humidity, atmospheric pressure and altitude. The combined data is optimized and transmitted via 4G GSM and delivered via an e-mail client and mobile application. The field testing of wireless smart trap at CICR Farm, Coimbatore showed a weekly mean trap catch of 19.8 (*P. gossypiella)*, 6.18 (*S. litura*), 0.19 (*H. armigera*) and 0.08 (*E. vittella*) during the season 2021–22. The cost of fabrication was ₹14,430/ trap with a recurring amount of ₹1,447 for GSM data and sticky liner replacement. The smart trap can be used for area-wide pest monitoring and the recurring cost can be minimized with cost-effective data transmission using Long Range Radio (LoRa) technology. By investigating the real-time trap catch with corresponding weather data, the area-wide pest dynamics could be integrated with a pest forewarning system for cost-effective pest management in cotton.



Schematic diagram of CICR Wireless Smart Trap

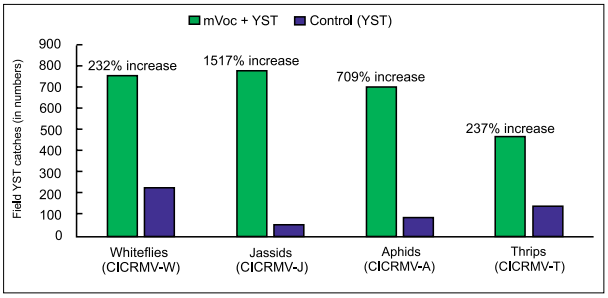
CICR Wireless Smart Trap



Trap catch with corresponding weather data

Microbial-based volatile compounds to trap sucking pests in cotton: Among several eco-friendly options for pest management, bioprospecting microbial-based volatile compounds (mVOCs) are novel and hopeful. mVOCs are small, odorous, low molecular weight compounds, with high vapor pressure and act as a long-distance messenger. Based on the pest attraction efficiency, four mVOCs formulations were short-listed from 150 mVOCs combinations and evaluated @5 ppm concentration on the attraction of major sucking pests of cotton (whiteflies, jassids, aphids and thrips) using yellow sticky traps (YST) in a large-scale replicated field trails at Nagpur, Coimbatore and Sirsa. The mean field trap catches were counted at 40–80 days sucking pest window and expressed as a percentage increase over the control. Among the mVOCs formulations, CICRMV-W, CICRMV-J, CICRMV-A, and CICRMV-T trapped 232%, 1517%, 709% and 237% fold higher whiteflies, jassids, aphids and thrips as compared to the control.

Further, other mVOCs formulations selectively attracted beneficial insects including predators and parasitoids to the cotton plants. Treating cotton seeds with mVOCs was found to act as biostimulants. Based on the literature survey, the short-listed mVOCs are found to be safe and find a place in our day today use as per the toxicological data available. Currently, these formulations are being evaluated under the AICRP on Cotton in central, north and south cotton growing zones of India.



Microbial-based volatiles on attraction of cotton sucking pests

Field installed yellow sticky traps (YST)

Control trap with solvent

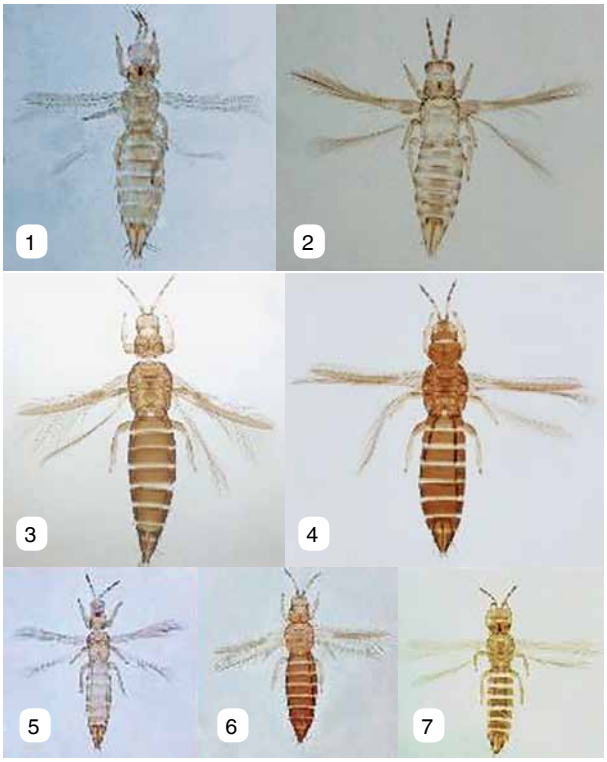
Aphids and thrips attraction

Whiteflies and jassids attraction

Potential entomopathogenic fungi for fall armyworm (FAW): Fungal bioagents provide an effective alternative for ecofriendly management of FAW. Variability among the isolates of entomopathogenic fungi (EPF), from different geographical locations and their efficacy against insect-pests was noticed in earlier studies. Therefore, it is important to exploit native EPF and to test the efficacy against FAW for developing a bioagent. Larvae infected with EPF were collected from the sorghum field (new area farm) during October 2021. The fungal strains were cultured on Sabouraud's maltose yeast extract agar (SMYA) and spindle shaped conidia of *Metarhizium rileyi* were noticed under microscope. Insect bioassay was conducted to study the efficacy of the native strain of the *M. rileyi* on FAW. *In vitro* tests revealed the potential of *M. rileyi* as microbial agent for management of the fall armyworm in sorghum. This needs further evaluation for its efficacy at lower concentrations and also under field conditions.

Field collected FAW larva infected with entomopathogenic fungus

Diversity of thrips species on cotton: An exploratory survey was carried out to study the diversity of thrips species on cotton at Coimbatore, Tamil Nadu revealed the presence of *Scirtothrips dorsalis*, *Thrips palmi* and *Thrips tabaci* on leaves and *Thrips florum*, *Thrips hawaiiensis*, *Frankliniella schultzei* and *Thrips parvispinus* on flowers. *Thrips parvispinus* is one of the notorious pest species of south East Asia and also a serious pest of quarantine importance. The invasion and infestation of *T. parvispinus* on cotton was reported for the first time in India. As *F. schultzei*, *S. dorsalis*, *T. palmi* and *T. tabaci* are the vectors of plant viruses, and hence regular monitoring is needed in the cotton ecosystem to decipher the pest dynamics.



Thrips species: 1, *Frankliniella schultzei*; 2, *Scirtothrips dorsalis*; 3, *Thrips hawaiiensis*; 4, *Thrips florum*; 5, *Thrips palmi*; 6, *Thrips parvispinus*; 7, *Thrips tabaci*

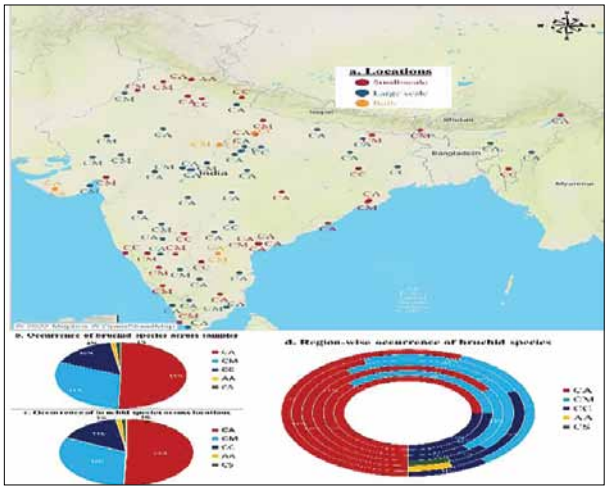
Classical biological control of cassava mealybug: Invasive cassava mealybug, *Phenacoccus manihoti* threatens the livelihood of tapioca farmers. The ICAR-National Bureau of Agricultural Resources (NBAIR), New Delhi imported a parasitoid, *Anagyrus lopezi* from IITA, Republic of Benin, West Africa as per Government of India guidelines during August 2021. The mandatory quarantine studies on the biology, safety and host specificity of the *A. lopezi* was undertaken at the NBAIR QC-2 quarantine facility to ensure its non-target impacts.

First release of *Anagyrus lopezi* in cassava at Yethapur

Distribution and release of *Anagyrus lopezi* in cassava at Erode district, Tamil Nadu

ICAR-NBAIR on optimizing the production and release protocols organized trainer's training programmes for officials of State Agricultural Universities, State Horticulture Departments and Krishi Vigyan Kendras in Tamil Nadu and Kerala. On obtaining the field release permit, the first field release programme of the parasitoids and its distribution to the cassava farmers have been organized by ICAR-NBAIR at Yethapur, Salem district of Tamil Nadu on 7 March, 2022. About 300 tapioca farmers from 6 districts of Tamil Nadu attended the event. The second release cum awareness programme by ICAR-NBAIR was conducted at KVK, Namakkal, Tamil Nadu on 23 April, 2022. In continuance, ICAR-NBAIR organized the third farmers training cum awareness programme on classical biological control of cassava mealybug on 23 September, 2022 in Erode district of Tamil Nadu. More than 200 tapioca-growing farmers attended and benefitted.

Common bruchid species harbouring edible stored legumes across India: The survey was conducted to understand the infestation, distribution and diversity indices of common bruchid species infesting edible stored legumes in India. A total of 81 infested stored grain samples representing 13 pulses and 1 oilseed crops were surveyed from 74 locations spread across 24 states. Five bruchid species were identified, infesting samples were confirmed through morphological and molecular approaches. Three of which were *Callosobruchus* species found cosmopolitan on maximum samples, locations and crops. Among *Callosobruchus* species, *C. analis* was distributed on 50% of the samples and locations, followed by *C. maculatus* and *C. chinensis*. Despite *C. analis* being present in the majority of samples, *C. maculatus* was the most abundant and dominant species as far the density of the beetles were concerned. Six of the 24 states recorded all 3 *Callosobruchus* species, 8 states recorded any 2 of the 3, and the other 10 states recorded any 1 of the 3 *Callosobruchus* species. *C. analis* and *C. chinensis* were abundant in 4 of the 6 regions, while C. chinensis in north-east region.



Distribution of bruchid species on edible stored legumes across different locations of the country (Note: CA, *C. analis*; CM, *C. maculatus*; CC, *C. chinensis*; AA, *A. obtectus*; CS, *C. serratus*)

Microbe-based technologies for control of *Erysiphe necator* causing powdery mildew disease in grapes (*Vitis vinifera*): The microbe-based technologies, i.e. Eco-pesticide (a liquid bioformulation of *Pseudomonas fluorescens* PF-08), Bio-Pulse (a talc-based bioformulation of *Trichoderma asperellum* UBSTH-501 and *Bacillus amyloliquefaciens* B-16), and Bio-Care 24 (a liquid bioformulation of *Bacillus subtilis* RP-24) developed at ICAR-NBAIM, Mau were evaluated against grape powdery mildew and integrated with a safer fungicide (sulfur) to achieve better disease control under organic systems of viticulture. These technologies were evaluated at 4 different locations, viz. the vineyards of ICAR-NRCG, Rajya Draksha Bagayatdar Sangh (MRDBS), and 2 farmers' fields at Narayangaon and Junnar in the Pune district of Maharashtra. A significantly lower per cent disease index (PDI) was recorded on the leaves of grape plants treated with Eco-Pesticide®/sulfur (22.37) followed

Untreated control Bio pulse + Sulphur Eco-pesticide+Sulphur

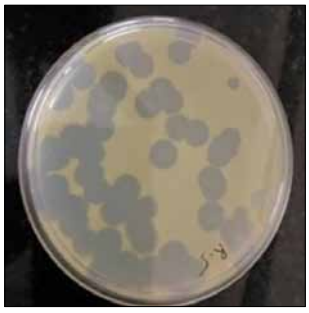
Effect of microbial technologies on disease incidence in grape

Untreated control Bio pulse + Sulphur Eco-pesticide+Sulphur

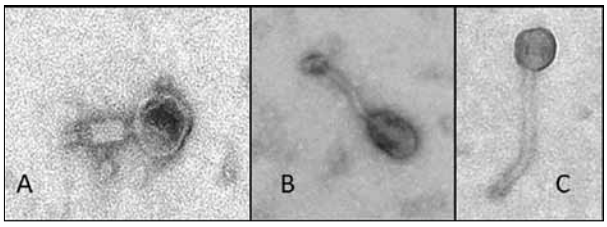
Effect of microbial technologies on yield in grape

by Bio-Pulse®/sulfur (22.62) and Bio-Care 24®/sulfur (24.62) at NRCG.

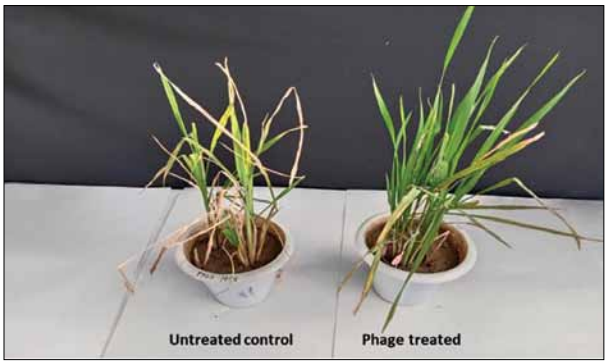
Identification of novel bacteriophage NR-08 against *Xanthomonas oryzae* pv. *oryzae* having potential bio-control efficacy against bacterial leaf blight of rice: Bacterial leaf blight (BLB) disease of rice caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*), is one of the most destructive diseases worldwide causing more than 50% yield losses. An eco-friendly alternative to chemical anti-bacterials like phage therapy was explored at ICAR-NIBSM, Raipur as potential bio-control option for the control of BLB. A diverse group of 19 bacteriophages having lytic potential against wide range of *Xoo* pathogens were isolated from rice field water, soil and field debris. Based on Transmission Electron micrographs and whole genome sequence, these phages showed the varied diversity belonging to phage family *Podoviridae, Siphoviridae* and *Myoviridae*. The genome size of these phages ranged from 43.6 to 203 kb with predicted number of genes from 56 to 418. The raw sequence data were submitted to NCBI under the Bio-Project: PRJNA844261 with the SRA accession number: SRR19757542-56; and SRR19760374. The phages were viably active in wide range of temperature (4–50°C) and *p*H (5–9). The sequence analysis of NR-08 phage has shown the strong bacteriolytic lifestyle without any association of phage lysogenic cycle, antibiotic resistance and toxicity. The most of genome sequence information is novel to this phage having no similarity with previously known phages. On bacterial challenge assay, the NR-08 phage has bacteriostasis potential up to 24 h and showed 99.95% reduction in bacterial viable count in 48 h. During the *In-planta* phage efficacy trials in rice pots, the application of phage NR08 treatment significantly reduced the BLB lesions on rice leaves and showed more than 75% protective efficacy as compared to the untreated infected control. This novel NR-08 *Xoo* phage may be explored further as an efficient, potent and valuable candidate for bio-control of bacterial leaf blight of rice.



Plaques of phage on overlay agar



Electron micrograph of Bacteriophages: *Myoviridae* (A), *Siphoviridae* (B, C)



Significant reduction of BLB symptoms in phage treated rice plant leaves as compared to untreated control plants

Patent granted for 'Multi-use composition for biocontrol of plant pathogen infestation': ICAR-National Rice Research Institute, Cuttack has identified two *Trichoderma* species having excellent quality to protect the rice plant from the soil and seed-borne diseases and excellent growth promotion capability. The research team developed a formulation with these two species individually and in combination and tested in farmers' fields. These formulations were observed to be highly effective in different crops including maize, finger millet, niger and rice. It was observed that using these formulations, the farmers were able to harvest 10–20% higher yield with lower input. Besides reducing the use of chemical fungicides, it also reduces the input of chemical fertilizers. The inventors filed a patent based on the formulation on 'A multi-use composition for biocontrol of plant pathogen infestation, and growth Enhancement' which has been granted recently by the Indian Patent Office on 3 December, 2021 (Patent No. 383679).

Management of leaf blight/wilt in Rajasthan: The disease can be controlled with the combined practice involving (1) Seed treatment with tebuconazole 2 DS @1.5 g/kg/seed; (2) Four rows of bajra in between groundnut (6 groundnuts: 4 bajra: 6 groundnuts per plot) with 43.0% decrease of disease over control having 506 I.C.B.R.; (3) Application of neem cake @200 kg/ha (Basal) with 20.3% decrease of disease over control having 2.0 of I.C.B.R and soil application of *Trichoderma* powder 10 kg/ha at basal, 30, 55 and 75 DAS with 24.0% decrease of disease over control having 7.4 I.C.B.R.; (4) Spraying of carbendazim 12% + mancozeb 63% WP (SAAF 75% WP) (10 g SAAF in 5 L water for 100 sq m area) with 20.5% decrease of disease over control having 22.7 of I.C.B.R.; (5) Tebuconazole 430 SC (@7.5 ml folicure in 5 L water for 100 sq m area) at 30, 55 and 75 DAS with 30.0% decrease of disease over control having 10.5 of I.C.B.R.

Commercialization of Entomopathogenic nematode (EPN) biopesticide formulation technology: The ICAR-SBI, Tamil Nadu, EPN biopesticide formulation technology has been commercialized to 5 companies (Coordinated by Agrinnovate India, New Delhi) with a license fee of ₹10 lakhs. The 78 EPN strains belonging to tropical (49) and subtropical (29) are being maintained in the culture collection and 45

symbiotic bacteria of *Photorhabdus* spp. (26 Nos.) and *Xenorhabdus* spp. (19 Nos.) are also being regularly sub-cultured and stored in glycerine.

Rice research for upland, coastal area and low-land ecology: During 2021, the 766 accessions of rice germplasm were maintained. Efficacy of fungicide against rice bakanae disease was tested and observed that spraying of propiconazole @2 ml/litre of water at 15 days after transplanting (DAT) recorded the lowest incidence of bakanae disease and higher yield. Crop transplanted in first fortnight of February recorded lowest incidence of rice stem-borer (0.76%) and highest yield as compared to late planting.

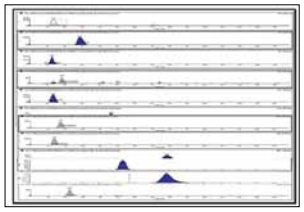
Bio-control of parasitic weed *Striga* spp. in sugarcane: Soil application of mycorrhizal consortium @20 kg along with 500 kg of compost/ha at the time of sugarcane planting resulted in suppression of parasitic weed *Striga* spp. emergence by 38%, and increased the sugarcane yield by 13.50% with a Benfit cost (B:C) ratio of 2.51 (AICRP-WM Centre of ICAR-DWR, Jabalpur at UAS, Dharwad).

UASD AMF consortium (native)

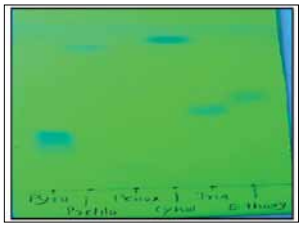
Control

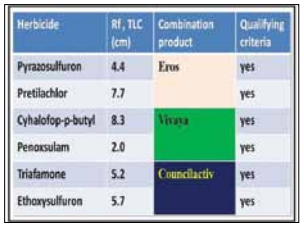
Multi-residue analysis method for determination of herbicide residues: A multi-residue analysis method was developed by the ICAR-DWR, Jabalpur for simultaneous determination of 30 herbicides in agricultural commodities using LC-MS/MS. Similarly, a multi-residue analysis method using TLC with the detection limit of <0.01 µg/g was also developed for determination of herbicide combination products, viz. pretilachlor + pyrazosulfuron, cyhalofop-p-butyl + penoxsulam and traifmaone + ethoxysulfruon.

LCMS/MS



Detection of herbicide residues in LCMS/MS

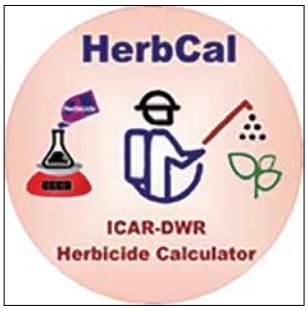




Herbicide	Rf, TLC (cm)	Combination product	Qualifying criteria
Pyrazosulfuron	4.4	Eros	yes
Pretilachlor	7.7		yes
Cyhalofop-p-butyl	8.3	Viraya	yes
Penoxsulam	2.0		yes
Triafamone	5.2	Councilactiv	yes
Ethoxysulfuron	5.7		yes

Simultaneous detection of six herbicides by TLC

Herb-Cal: A new multi-language mobile app to calculate herbicide dose: ICAR-Directorate of Weed Research, Jabalpur has developed a user friendly multi-lingual mobile app named 'Herb Cal' for application of herbicides. After entering the herbicide information such as crop, area, dose and herbicide formulation to be used, the app automatically calculates the amount of herbicide and quantity of water to be taken for spray. This app is available on Google Play Store.



Biological control of alien invasive weed *Salvinia molesta* in central India: Water fern (*Salvinia molesta*), an alien invasive aquatic weed earlier reported in Kerala, has recently been observed in Satpura reservoir in Sarni town of Betul district and 3- 4 aquatic ponds in Jabalpur and Katni districts of Madhya Pradesh. The weed has adversely affected irrigation, hydroelectric generation, water availability and navigation besides drastic reduction in production of fish and aquatic crops (chestnut). Non-availability of label-claim herbicides for aquatic weed management, high cost of mechanical removal and regeneration thereafter are some of the major challenges for its management. Therefore, biological control was considered as an eco-friendly and cost-effective method for its management.

A host specific insect *Cyrtobagous saliviniae*, known to be an effective bioagent against *S. molesta*, was brought to the Directorate of Weed Research, Jabalpur for testing its bio-efficacy and further multiplication. To demonstrate the technology, a 20 ha *Salvinia* infested pond in village Padua of Katni district was selected for release of bioagent in consultation with the villagers and Sarpanch (head of the village). It was told by the Sarpanch that the pond was severely infested for last three years and all the efforts of manual removal by the villagers were in vain. Initially, 2000 adult weevils of bioagent *C. saliviniae* were released in the infested pond in the month of December, 2019. The bioagent started multiplying in the pond gradually. Initially up to 6 months, there were no visible symptoms of the damage but gradual increase in insect population was recorded. Bioagent population increased from negligible to 125.5 adults per meter square in 11 months and started to decline in due course with the decrease in population density of the weed. With the increase of bioagent population 50, 80 and 100%, control of *S. molesta* was achieved by 8, 11 and 18 months, respectively. The insect kills the weed by feeding on terminal buds and new growth while its larvae tunnel through buds and rhizomes. Killing of terminal buds checks the regrowth of the weed.

Salvinia molesta infested pond before release of bioagent

Release of bioagent in December 2019

Brown patches showing killing of weed due to bioagent

50% clearing of pond by 8 months after release of bioagent

80% control by 13 months after release

Complete control by 18 months

Integrated Farming System model for enhancing system productivity in transitional plain of Luni Basin: An integrated farming system model for enhancing productivity and profitability in transitional plain of Pali was developed for 1 ha area also compared with the conventional farming system. Integrated farming system comprising 70% area for crop production, 27% area for fruit and vegetable production and 3% area for livestock in which goat unit comprising 5 females and 1 male were taken. Boundary plantation with *Ailanthus excelas* (Ardu) was done. In crop production component, sorghum, cluster-bean, greengram in *kharif*, wheat, mustard, cumin in *rabi*; fodder sorghum, fodder pearl millet and summer greengram were taken during summer in integrated farming system and in conventional farming system sorghum, cluster-bean, greengram in *kharif*, wheat, mustard and cumin in *rabi;* season. Fruits and vegetable in horticulture component were accommodated in 27% area. Pomegranate, guava and ber, and within row space papaya were taken as fruit and in between rows of fruits lady finger, brinjal, bottle guard in *kharif*; onion, garlic, carrot in *rabi*, ladyfinger, water melon and muskmelon in summer were taken. The Integrated farming system model was found nearly three times more beneficial than conventional farming system.

HORTICULTURE

Crop Production

Fruit crops

Vertical expansion of nursery under protected conditions using soilless rooting medium: An efficient technology for multiplication of clonal rootstock (M-9, MM-106, MM-111, P-22, B-9, M-27) of apple under greenhouse conditions was standardized. The technique involves wounding/incision on branches with diameter of 5 mm at 30 cm above ground level using sharp knife/ blade to remove the bark followed by application of 2,500 ppm IBA as rooting hormone. The treatment starts from the second week of June till the last week of August. Small polybags (filled with rooting medium) are fastened at the points where rooting needs to be initiated. A lightweight substrate (cocopeat) having high moisture holding capacity is used as rooting medium. Staking is accomplished with the help of bamboo poles to hold the bags in a proper position and to keep the plants straight. This technology is very useful in promoting the vertical expansion of the nursery in greenhouse conditions and the multiplication of number of plants per unit area has increased by three to four times with minimum utilization of extra inputs and area. One more additional benefit of this technology is that under the greenhouse conditions, the rootstocks attain sufficient girth (> 6 mm) and all the plants are suitable for budding. The technology not only produced the additional 3-4 rootstocks but also the budded plants which have added advantage to this technology.

Multilayer multiplication technology of clonal rootstocks of apple by air layering under protected conditions

Field evaluation of consortia of phosphate solublizing bacteria with different phosphorous level in banana cv. Ney Poovan: Field evaluation of consortia of phosphate solubilizing bacteria (PS1 and PS2) showed that application of 100% single super phosphate (SSP) + PS1 + PS2, recorded 172.44% increase in available phosphorus in soil, and 188.72% increase in available phosphorus in leaf followed by application of 100% rock phosphate (RP) + PS1 + PS2 (158.24% and 159.97% increase in soil and leaf respectively). Besides, application of 100% SSP + PS1+ PS2 improved plant growth characters.

Nutrient management in custard apple: Application of 100% RD of N-P_2O_5-K_2O + vermicompost 6 kg per plant was found to maintain sustainability and is recommended by Jadhavwadi Centre to obtain maximum yield and net income for custard apple cv. Purandar Local.

Site Specific Nutrient Management: SSNM with secondary ($CaSO_4.2H_2O$ – 1 kg and $MgSO_4$ – 500 g per palm per year) + Micronutrient mixture ($FeSO_4$, $MnSO_4$, $CuSO_4$, $ZnSO_4$, Borax and ammonoium molybdate) @ 1 kg per palm per year + Coconut frond mulching + *Azospirillum* – 100 g + *Phosphobacteria* -100 g + VAM - 100 g per palm per year enhanced productivityby 32% over farmers' practice in Tender nut variety Chowghat Orange Dwarf. Net Returns and Benefit cost ratio were ₹ 4.38 lakhs per ha and 2.99 in INM package as against ₹ 3.10 lakhs per ha and 2.66 in farmer's practice.

Scheduling of irrigation and fertigation in guava: Irrigation scheduling to meet 60% evaporation during the vegetative and reproductive phases can realize higher productivity (29.84 t/ha) and water use efficiency (11.86 kg/m^3), coupled with a water saving of 2729.10 m^3/ha accounting to a saving of 23.57% of water with a water use efficiency of 11.86 kg/m^3 in Guava cv. Arka Mridula.

Overcoming uneven ripening in grape: To overcome the problem of uneven ripening in grape variety Gulabi, it is recommended to retain 50 bunches per vine and treating bunches with 300 ppm of ethrel at various stage (berry softening) to produce bunches having uniform colour (measured as anthocyanins) and high TSS.

Technology for Propagation of Clonal Rootstocks of Apple through Cutting under Greenhouse in Soilless Beds

Sunken beds of dimensions 2.5 0 ft (76 cm wide) and 1.0 ft (30 cm) depths were prepared. After preparing the sunken beds, the beds were filled with sand and cocopeat. The lower 6 inches (15 cm) of the bed were filled with sand while the upper 6 inches (15 cm) were filled with cocopeat. The purpose of digging out soil from the beds is to fill it with sand and cocopeat to make soilless beds conducive for planting the cuttings, and to avoid weeds and reduce the water requirement considerably. The cuttings of 30 cm size of pencil thickness (8-10 mm) with 8-9 buds were selected and planted in the first week of March in these beds. The lower portion of the cuttings was given a horizontal cut and light cut on either side of the cutting at the base to expose more of the cambium for callusing. Before planting, the cuttings were given fungicidal treatment (Carbendazim 3 g/litre of water) for 20-25 seconds and dipped in rooting hormone Indole Butyric Acid IBA (2500 ppm) for 10-15 seconds. The cuttings were planted in the soilless beds at a spacing of 3 inches (7.62 cm) both in a row-to-row and cutting-to-cutting to accommodate 52 cuttings per sq. meter area. With this technology, 40-45 plants with well-developed root systems were harvested per square meter area of the soilless beds. This technology will revolutionize the production of clonal rootstocks in the country from the wasted portion of the plant. By adopting this technology, the cost of rootstock/planting material will get reduced and dependence on import for quality planting material will decline drastically.

Different stage of Nursery development using by cuttings in soilless beds under protected conditions

With bunch thinning and ethrel application

Without bunch thinning and ethrel application

Standardization of growth stage wise nutrient and water requirement: Crimson Seedless vines raised on Dogridge rootstock showed that sub-surface irrigation treatment based upon pan evaporation and crop growth stage produced 18.25 t/ha of grapes utilizing only 216.1 mm of irrigation water with highest WUE of 84.4 kg grapes/mm of irrigation water applied.

Use of nanoparticles of iron and zinc: Nanoparticles of iron and zinc were fabricated through green route using grape (Manjari Medika) leaves and pomace extract and characterized. Field application showed a significant increase in leaf Fe (+30.28% and +36.59%) and Zn content (+20.90% and +28.39%) after 14 and 28 days of application of Fe-NPs and Zn-NPs over conventional fertilizers.

Rootstock valuation trial: The performance of Crimson Seedless, Manjari Kishmish and Manjari Medika grapevines grafted on Dogridge and 110R was found superior over other rootstocks based upon growth, yield and berry quality parameters. In case of Manjari Naveen, significantly higher yield, bunch weight and leaf area was recorded in vines raised on 1103P than other rootstocks. In the experiment to study the response of grape rootstocks, under drought and water-logging conditions, the results of bio-chemical, root morphological and anatomical parameters revealed that 140Ru, 110R, SO4 and Dogridge rootstocks performed better under drought condition whereas 1103P, 110R and 140Ru rootstocks performed better under water-logging condition. The rootstock 110R and 140Ru performed better under both the conditions. The light curve measure under field condition showed that grape cv. Thompson Seedless grafted on Dogridge rootstock had light saturation at approximately 1200-1300 µmol $m^{-2}s^{-1}$ and light compensation between 20 to 30 µmol $m^{-2}s^{-1}$ at veraison stage.

CISH-Decomposer (compost booster): ICAR-CISH, Lucknow developed a microbial consortium of microorganisms that has potential in accelerating the composting rate. The product proved to be useful in fast degradation of complex organic substrates and the compost obtained through this method is rich in NPK content compared to traditional way of compost preparation. Now this novel technology is under process of commercialization to M/s. Ranaji Biotech (India) Pvt. Ltd, Kanpur.

Plantation crops

Standardization of raising oil palm seedlings in Pro-trays: The raising of oil palm seedlings in pro-trays during primary nursery was standardized at ICAR-IIOPR. Growth of seedlings grown in pro-trays by using vermicompost and empty fruit bunch fibre compost is better when compared with coco-peat compost.

CISH Decomposer

Impact of oil palm cultivation on soil properties and nutrient availability: The impact of oil palm cultivation on soil properties and nutrient availability has been established. Oil palm cultivation enhanced pH, EC, soil organic carbon, soil available sulphur, exchangeable calcium and magnesium. Soil available phosphorus increased with plantation age. Oil palm cultivation also enhanced SOC stock by 20, 18 and 45% in 6, 12 and 18 years old plantations.

Water productivity in different irrigation methods: The various techniques for higher water productivity, viz. plastic mulching, inline drippers, *in situ* mulching with oil palm fronds, were compared with drip and microjet systems under different levels of deficit irrigation in oil palm plantations. Among different treatments, water usage per each kg of FFB was very high under microjet irrigation. Plastic mulching with 50% water requirement used minimal water per kg FFB produced. However, plastic mulching could save 25% water with higher sustainability index both under drip and inline dripper system of irrigation. Lowest sustainability index was recorded under microjet irrigation without *in situ* mulching followed by microjet irrigation with *in situ* mulching.

DRIS indices and critical leaf nutrient concentrations developed for oil palm plantations: The DRIS indices for Nellore district are -4.38, 2.03, 2.93, 1.32 and -2.24 for Nitrogen, P, K, Mg and B respectively. Nitrogen (N)>B>Mg>P>K is the order of importance of nutrients in oil palm growing regions of Nellore district. Nitrogen and Boron are the most critical nutrients in oil palm growing soils of Nellore district.

Cashewnut production management: Eight principal growth stages including the critical stages for vulnerability to pest attack were identified in cashew as per extended BBCH scale. It is recommended to prune 25% lateral shoots during the month of mid-September for obtaining high yield in cashew variety Bhaskara under west coast conditions of Karnataka. It was found that a 20-year-old plantation of cashew on a highly weathered lateritic soil can sequester biomass carbon in the range of 42.93 to 50.41 MgCha which is equivalent to 157.56 to 184.99 Mgha of CO_2 equivalents. The total sequestration of carbon in the top 60 cm layer of soil of a 20-year-old cashew plantation ranged from 99.52 to 104.61 Mgha. During the 20th year of the plantation, the contribution of soil to the total sequestered carbon was 2 to 2.3 times of biomass carbon. Under a highly weathered environment, trees such as cashew further supplement the carbon sequestration capabilities of the soil.

Coconut-based Integrated Farming System (CBIFS) including banana and pepper as intercrops along with dairy, poultry and goatery realized a net

return of ₹ 6,53,853 from a unit area of one hectare. The C:B ratio for this system was 2.08 indicating it as a successful model for coconut farmers to adopt. Groundnut (var. Girnar 2 and 3) was grown successfully as intercrop in coconut plantation. Application of 50% RDF + vermicompost @ 10 t/ha recorded higher pod yield of 2297 and 2092 kg/ha for G3 and G2 variety, respectively. The spacing dimensions of 0.6 m × 1.2 m was found to yield the best quill yield of 632 kg/ha from 290 cinnamon plants cultivated as intercrop in coconut.

Intercropping of seasonal horticultural crops under arecanut: The experiment at Kahikuchi depending upon the climate feasibility and preference of the local consumer suggest that winter and summer vegetables like cabbage (var.agheni), cauliflower (var. Madhuri), tomato (Vaishali), brinjal (var. Rani), okra (var. Gunjan) and ridge gourd (var. Rama) crops are suitable intercrops with a yield of 7.8 t/ha, 3.9 t/ha, 19.3 t/ha, 6.5 t/ha, 11.42 t/ha and 21.9 t/ha, respectively.

Shotgun Metagenomic Characterization

Shotgun metagenomic characterization of rhizosphere bacterial microbiome in the YLD endemic apparently healthy rhizosphere soil (YLD-AHR), YLD endemic disease intensive rhizosphere soil (YLD-DIR), and YLD endemic non-rhizosphere soil (YLD-NR) revealed that among the microbes, bacteria exhibited the highest taxonomical representation of 96.1 to 96.8% with the Proteobacteria (70.1% to 75.0%) as predominant bacterial phyla in arecanut YLD endemic rhizosphere. The most abundant classified genera were *Burkholderia, Variovorax, Paraburkholderia, Cupriavidus, Rubrivivax, Bradyrhizobium, Anaeromyxobacter, Sorangium, Sandaracinus, Pseudomonas, Sphingomonas, Thauera, Micromonospora, Rhodoplane, Rhodopseudomonas, Gemmatirosa, Methylobacterium, Myxooccus, Geobacter* and *Nitrospira.*

Vegetable crops

Organic farming trial on amaranths: At Dharwad (zone-VIII), the highest yield of 162.36 q/ha with B:C ratio of 3.06 was recorded by application of vermicompost @ 2 t/ha + PSB + *Azospirillum* @5 kg/ha each.

Weed management in cowpea: Study at Hisar, Jorhat and Dharwad (zone III, VIII and VI) revealed that the maximum pod yield of 80.5 q/ha with B:C ratio of 2.2 was obtained with pre-emergence application of Pendimethalin @ 6ml/L+ one hand weeding 25 days after sowing.

Grafting in solanaceous vegetables: In solanaceous vegetables, grafting was conducted using four rootstocks (three brinjal IC 354557, IC 111056, Surya and one tomato wild *S. pimpinellifolium*) and three tomato scion cultivars (Kashi Aman, Kashi Adarsh and Kashi Chayan). The yield of Kashi Aman and Kashi Adarsh was unaffected, whereas yield of Kashi Chayan decreased by 22.3% as compared to non-grafted tomato. The yield of Kashi Aman was significantly enhanced over *S. pimpinellifolium.* Most of the fruit quality parameters were unaffected with grafting in tomato.

Experimental findings revealed that grafting tomato (Kashi Aman, K. Adarsh and K. Chayan) on brinjal rootstocks (IC 11056, IC 354557 and Surya) did not affect the yield of Kashi Aman and Kashi Adarsh, however it reduced the yield significantly (29%) in Kashi Chayan variety. In other grafting experiment, use of *Solanum pimpinellifolium* as rootstock enhanced the yield of Kashi Aman by 22.3% as compared to ungrafted Kashi Aman. Yields of Kashi Aman on other wild species *S. torvum* was at par to ungrafted plants.

Neelima hybrid on brinjal Surya rootstock at Vellanikkara (zone-VIII) revealed that highest fruit yield of 395.2 q/ha with B:C ratio of 3.2 and net return of INR 4,36,820/ was obtained. No incidence of bacterial wilt and root knot was observed in this graft combination.

Screening of Okra for Drought Stress Tolerance

Twenty four okra genotypes were grown in field conditions for the screening of drought stress tolerance genotypes. Drought stress was imposed by withholding irrigation at the reproductive stage and the physiological, biochemical and yield data were recorded. The preliminary data indicated that VRO 102 genotype had higher total chlorophyll content, membrane stability index and relative water content after 20 days of withholding of irrigation.

Intercropping of coriander in bearing arecanut palms: Burmese coriander is a popular herb grown in the Andaman and Nicobar Islands. The herb was grown as an intercrop in bearing arecanut palms of variety Samrudhi to study the profitability of this herb as an intercrop in the warm humid tropical conditions of South Andaman Island. Results suggested that introduction of Burmese coriander in the interspaces could give higher net returns of ₹ 13,03,065 as against ₹ 9,59,600 in the arecanut sole crop. The B:C ratio of this treatment was 3.19 and hence, it could be recommended for the island farmers.

Integrated Nutrient Management in tuber based cropping system: A field experiment on the effect of inorganic and organic manures on soil quality, yield and proximate composition of yam + sweet corn cropping system in an Alfisol of eastern India showed significantly highest tuber yield (25.16 t/ha) due to integrated application of FYM @ 16t/ha in combination with 40-30-50 kg N, P_2O_5 and K_2O/ha and $MgSO_4$ @ 25 kg/ha at par with FYM + ½ NPK + $ZnSO_4$ (24.66 t/ha). The study indicated that integrated use of FYM along with half of the recommended doses of NPK fertilizers and $MgSO_4$/ $ZnSO_4$ not only enhanced the productivity of greater yam but also sustains the soil quality parameters.

Application of customized fertilizers in sweet potato: Under fertilizer best management practices in sweet potato, application of customized fertilizers developed by ICAR-CTCRI @ 300 kg/ha as basal and

one month after planting followed by foliar application of micronol sweet potato @ 5 ml/litre three times on 15, 30 and 45 days after planting was found to be the best for higher tuber yield (22.74 t/ha) compared to present POP (19.67 t/ha) and recorded 15.61% higher yield over control was recommended for eastern plateau and hills, lower gangetic plains, middle gangetic plains, southern plateau and hills, and Gujarat plains and hills.

Standardization of nutrient requirement of swamp taro: Standardized the nutrient requirement of swamp taro (Kalyani, Jorhat, Imphal, Lembucherra and Thiruvananthapuram). Application of FYM 15 t/ha + N-P_2O_5-K_2O 120-60-90 kg/ha recorded significantly higher stolon yield (25-30.14 t/ha i.e. 21% higher than control) and recommended for Eastern Himalayan, and Western Himalayan zones.

Mushrooms

Production technology of *Macrocybe gigantea*, (Arka MG-1): An edible mushroom, suitable for tropical regions having temperature range of 30-40°C was standardized. It is nutritious with good levels of protein, fibre, potassium, calcium and iron.

Production technology of *Pleurotus tuber-regium*, (Arka PT-1): An edible mushroom suitable for tropical region with a temperature range of 30-35°C was standardized. It is highly nutritious having high levels of protein (40.34%), fibre (16.49%), iron (9.96 mg/100 g) and zinc (9.13 mg/100 g).

Development of cultivation technologies of *Panus lecometi*: Attempts were made for cultivation of this mushroom under controlled conditions using the sawdust-based substrate. The specimen was characterized by its purplish fruiting body having coarse, rigid dense hairs on cap and pubescent stipe and abundant metuloids.

Panus lecometi

Induction of fruiting in *Morchella importuna* strain ANI1: In third successive trial on induction of ascomata of *Morchella importuna* strain ANI1, 350 ascomata were induced in 2022. Heterothallism kind of sexual reproductive mode was established in ANI1. During ascomata induction trial, ANI1 took 120 days to reach the stage of maturity in the growing beds. Upon complete colonization of growing beds as evidenced by visible growth of *Morchella* mycelium in the beds, nutrition pouches were kept in the beds to supply nutrition and to induce reproductive stages of *Morchella importuna* strain ANI1, imperfect stage of *Morchella importuna* strain ANI1 which is also known as powdery growth. Asexual stage of the fungus produced septate hyphae and highly branched conidiophores. A single conidium was found on a phialide. Conidia noticed small and round in shape. The ascomata was obtained with ladder-like pattern of pits and ridges on the surface of pileus, 4–15 cm high and conical or occasionally egg-shaped. On the pileus surface, vertical and horizontal ridges made a laddered appearance. The ridges were pale to dark gray when young, but dark grayish brown to nearly black at maturity. Caping hollow with whitish flesh. The ascospores were elliptical and smooth whereas asci cylindrical, hyaline (translucent) and eight-spored.

Ascomata formation in *Morchella importuna* strain ANI1 during third trial in 2021-22

Low Cost Technology for the Paddy Straw Mushroom Cultivation

Paddy straw mushroom was cultivated in tunnel pasteurized paddy straw substrate in plastic crates (PC) and polyethylene (PE) bag, and bed along with room pasteurized cotton waste substrate. The biological efficiency (BE) was analyzed in the tunnel pasteurized paddy straw substrate. The BE of the room pasteurized cotton waste substrate was used as a control. In PE bag, BE was found higher then PC, bed system and room pasteurized cotton waste substrate.

Cultivation of DMRO-484 and DMRO-463 strains of the paddy straw mushroom

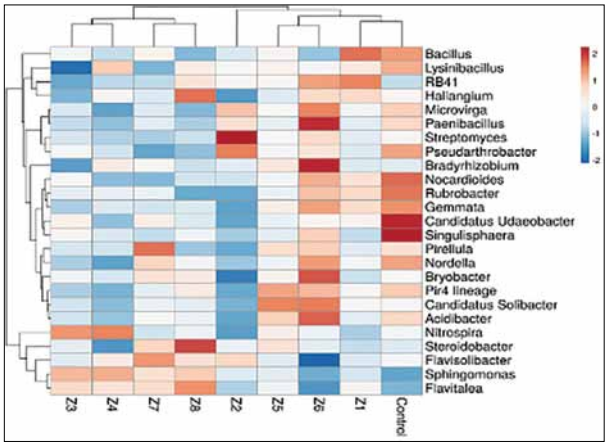
Flower crops

Vertical farming was standardized for growing important high value flower crops like Gerbera and Lilium by utilization of 11 feet vertical space of the polyhouse. This will increase the planting density and yield and reduction of water requirement significantly.


Spice crops

Developed nutritional and chemical fingerprints of popular turmeric varieties: Seventeen turmeric genotypes were characterized for different quality parameters and among the genotypes, seven varieties considered as high curcuminoid varieties (curcumin > 4%). Lowest curcumin and oleoresin were observed in Santra (0.24% and 5.52%). All the varieties recorded essential oil greater than 4%, in which Rajendra Sonia and Varna had significantly high essential oil (6.40%).

Effects of nano ZnO on soil microbial communities: The effects of nano ZnO (nZnO) on the compositional and functional responses of bacterial communities in soils were examined using high throughput sequencing. The heat map visualization with hierarchical clustering of the relative abundance (RA) of top 25 phyla and genera showed distinct differences in bacterial community structure. Dominant phyla like Proteobacteria, Firmicutes, Actinobacteria, Planctomycetes, Acidobacteria, Chloroflexi and Bacteriodetes accounted for 80% RA, while Verrucomicrobia, Gemmatimonadetes, Nitrospirae, Cyanobacteria and Patescibacteria contributed 10% RA. In general, Zn addition as nZnO or bZnO caused significant variations in the bacterial community composition.



Cluster heat map of the shared (a) phyla among the treatments [C: Control, Z1- 50; Z2- 200; Z3-500; Z4-1000 mg Zn kg -1 as nano ZnO; Z5-50, Z6-200, Z7-500, Z8-1000 mg Zn kg -1 as bulk ZnO]

Effect of organic, conventional, and integrated management practices on productivity and quality of turmeric varieties: Effect of different management systems on soil nutrient availability of turmeric at 120 DAP indicated that the organic carbon, nitrogen, calcium, and iron were higher under the organic management system. Effect of different management systems on yield of turmeric varieties indicated that INM 50-50 management system recorded maximum yield (30.3 t/ha) that was at par with organic (29.14 t/ha). Among the varieties, Pragati recorded the highest yield (51.88 t/ha). Response of Turmeric varieties to organic farming revealed that Suguna and Pragati recorded maximum yield (56 t/ha).

Microbial consortia for enhancing the growth and yield of cumin and coriander: Application of*Pseudomonas aeruginosa* DCU-451 + PSB- *Bacillus subtilis* or *Bacillus pacificus* DCU 651+ PSB -*Bacillus subtilis* enhanced 13.01-18.45% seed yield in cumin. Application of *Bacillus paramycoides* DCU-22 + PSB-*Bacillus subtilis* enhanced 26.98% seed yield in coriander.

Micronutrient management in cumin: Application of half recommended dose of zinc, iron, manganese and boron as soil application along with their foliar spray is recommended for obtaining higher yield (684.6 kg/ha) and returns (3.96 BC ratio) in cumin.

Standardization of drip irrigation interval and method of micro-nutrient fertigation in fenugreek: Drip irrigation at four-day interval along with fertigation of all micronutrients is recommended for higher yield and higher economic returns from fenugreek. The water use efficiency of 7.93 and 8.98 kg/ha^{-1}mm^{-1} were obtained at 4 days interval drip irrigation at Jobner and Ajmer, respectively.

Evaluation of natural farming (NF) practices: Under the aegis of All India Network Programme on Organic Farming (AINP-OF), with ICAR-IIFSR as the lead centre, ICAR-CTCRI conducted a field experiment with nine treatments replicated thrice in RBD. The net income was the highest in NF-4, natural farming without whapasa (₹ 812234/ha). The B:C ratio was highest in NF-1, natural farming without *beejamrit,*


Vegetable cowpea (var. Anaswara)


Cassava (var. Sree Reksha)


Green gram (var. Co-8)

Natural farming experiment at ICAR-CTCRI

ghanajeevamrit and *jeevamrit* (4.51), which was at par with all the other NF treatments, except NF-3 (without intercropping). Long term experimentation is required for conclusive results and confirmation.

Organic nutrient management practices for Sarpagandha developed: Based on three consecutive years study, it was found that application of FYM (20 t/ha) recorded maximum primary root yield (10.40 q/ha), reserpine yield (78.95 kg/ha), net return (₹ 3,62,000/ha) and B:C (3.56) in Sarpagandha.

Crop Protection

***Ceratocystis fimbriata* specific primers developed:** Mango wilt disease caused by the fungus, *Ceratocystis fimbriata* has become a great constraint in most of the major mango growing regions of the country. Early detection of the pathogen in orchards is necessary for wilt management. ITS1 and ITS4 primers were used for specific detection in two isolates, CF-1 (583 bp) and CF-4 (611 bp). The sequences thus obtained were aligned using *C. fimbriata* CISH isolate (MF062274.1) and *C. fimbriata* isolates from other host plants like pomegranate, loquat, coffee, apple, and fifteen *Ceratocystis* spp. through ClustalW tool. Sequence variations were observed among the three isolates and the conserved regions were useful in designing specific primers. *C. fimbriatomima, C. manginecans* and *C. eucalypticola* were found more than 90% similar to the *C. fimbriata* isolates infecting mango and other host plants. Other than these three species, all other species were significantly distinct from *C. fimbriata*. Primer sequences which were unique to *C. fimbriata* were identified and produced the specific amplification of ~470 bp and ~350 bp, respectively in case of *C. fimbriata* DNA and absent in all other fungal DNA as well as negative control. This method is able to detect *C. fimbriata* causing mango wilt from soil samples, that enables application of integrated disease management strategy much before the symptom expression in orchards.

New Insect-pests in Banana

Fall armyworm, *Spodoptera frugiperda*, an alien invasive pest of maize, was found to feed on banana leaves and complete its lifecycle on banana. It was found on banana plants in the vicinity of maize fields in Trichy District, Tamil Nadu, and it was quite likely to have moved to banana from maize. Infestation of the Bondar's nesting whitefly, *Paraleyrodes bondari Peracchi* (Hemiptera: Aleyrodidae), a recently reported exotic invasive pest in India, was recorded on banana from Karur and Tiruchirappalli districts of Tamil Nadu. Severe infestation of bagworm, *Manathaal bipes* (Moore) (Lepidoptera: Psychidae), was observed on cv. Karpuravalli and totally 108 germplasm accessions were found to be infested by this species. This is the first report of this pest on banana. It is known to be a serious pest on various palms including arecanut, coconut, and oil palm.

Emerging insect-pests in litchi: Litchi stink bug (*Tessaratoma javanica*) and the Flower webber were recorded as emerging insect-pest attaining major pest status of litchi. The other important pests recorded were fruit and shootborer, leaf mite, leaf roller and bark eating caterpillar. Borer complex of litchi was most important as they extensively damaged the developing and matured fruits reducing the yields and marketability.

Surveillance of rhinoceros beetle infestation: Developed an algorithm based on object detection approach with an accuracy of 84.3% for surveillance of rhinoceros beetle infestation using unmanned aerial vehicle (UAV or drone).

Arecanut kernel decay: Identified ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Curculionidae) and its fungal symbiont *Ambrosiella roeperi* associated with arecanut kernel decay in Karnataka, India.

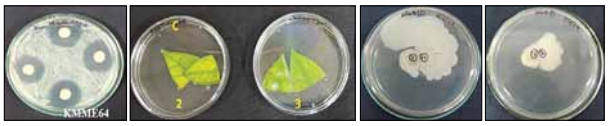
Mirid management in cocoa: An entomopathogenic fungus isolated from infected *H. theivora* was identified as *M. anisopliae* TMBMA1 and found to be effective in mirid management in cocoa.

Competitive regulation and biological control of rugose spiralling whitefly: Competitive regulation of rugose spiralling whitefly (RSW) by the Bondar's nesting whitefly (BNW) during 2021 was observed. The molecular identity of the entomopathogenic fungus *Simplicillium lanosoniveum* was confirmed by multilocus sequence typing.

Conservation biological control using the aphelinid parasitoid, *Encarsia guadeloupae*, neuropteran predators *Apertochrysa* sp. coccinellid lady beetles and the sooty mould scavenger beetle, *Leiochrinus nilgirianus* reduced the invasive potential of rugose spiralling whitefly (*Aleurodicus rugioperculatus*) on coconut. Ecosystem vitality and ecological integrity are restored with an economic benefit of worth ₹1760 crore.

Report of incidence of Fusarium wilt disease, tropical race 4 (Foc TR4) in banana in West Bengal: Incidence of Fusarium wilt disease in banana cv. Grand Naine was observed in Nadia District of West Bengal. Wilt incidence was from 10-50%. Based on vegetative compatibility group analysis and molecular analysis, the race was confirmed as tropical race 4 (*Foc* TR4).

Utilization of citrus microbiome in rejuvenating Khasi Mandarin plants affected by important citrus diseases: Samples collected from different parts of northeast India (Khamanpathar, Motapung, Tinsukia and Tripura) were examined for detection of HLB (Huanglongbing) by conventional and real time PCR showed the presence of HLB in these citrus regions. As many, 195 microbial cultures (62 endophytes; 68 rhizobacteria) (42 endophytes; 23 rhizobacteria) were isolated from healthy and infected Khasi mandarin orchards, respectively. Of them, 13 isolates showed antagonism against *Agrobacterium tumefaciens* EHA105 (a surrogate microbe to *C*Las). Comparative analysis of culturable microbial population in healthy and HLB-



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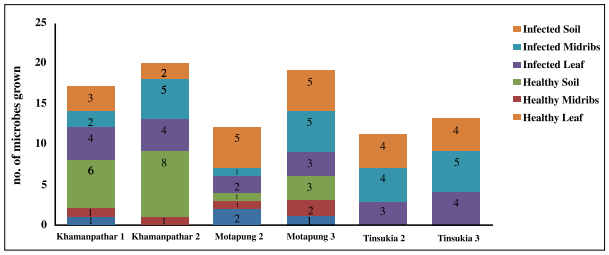
(i) Antagonistic activity of potential isolates against *Agrobacterium tumefaciens* EHA105. (ii) Leaf in untreated Luria broth; leaf treated with potential isolate. (iii) Positive interaction between isolates.

infected samples further showed higher abundance of microbial population in HLB-infected samples compared to those isolated from healthy samples. A novel citrus half-leaf method and *in vitro* assay evaluating two endophytes *(B. pumilus* and *B. safensis*) against *C*Las showed reduction in *C*Las copies in leaf material following 72 hours of treatment. As many as 48 microbial isolates identified and subjected to interaction studies for constructing PGPR-based consortium, consisting of 5 combinations being further examined for plant growth efficacy. Metagenomics analysis of endophytic microbial communities of healthy and HLB-infected Khasi mandarin revealed the structure and function and diversity of the microbiome. Total reads generated, for healthy and infected samples, 244693402 and 251827322, respectively with 90% of the reads having a Phred score over 30 (indicator of base quality in DNA sequencing). Taxonomic profiling reflected the reduction in alpha diversity in HLB-infected plants than healthy plants.



Comparative analysis of culturable microbial population in healthy versus HLB-infected samples

Management of citrus greening disease: Interim recommendation for management of citrus greening disease with 50% more than recommended dose of phosphorus + Tetracycline hydrochloride 600 ppm + $ZnSO_4$ 200 g + $FeSO_4$ 200 g was consistent in reducing the disease severity at Akola, Ludhiana, Periyakulam, Rahuri, Tinsukia and Tirupati.

Powdery mildew of ber: The farmers are advised to give three sprays of either myclobutanil 10% WP 0.04%. (ICBR 1:3.53) or Dinocap 48 EC @ 0.1 (ICBR 1:1.89) @ 2 ml/litre starting from the initiation of the disease and two subsequent sprays at 15 days interval for effective and economical management of powdery mildew of ber by the SK Nagar centre of Gujarat.

Management of fig rust disease: The farmers are advised to give three sprays of either Carbendazim 50% WP (0.1%) (ICBR 1: 20.73) @ 3.3 g/litre or Tebuconazole 25.9EC (0.1%) (ICBR 1:8.77) @ 3.86 ml/litre or Tebuconazole 50 % + Trifloxystrobin 25% 75 WP (0.05%) (ICBR 1:6.71) @ 0.67 g/litre starting from the initiation of the disease at 15 days interval for effective and economical management of fig rust disease by the SK Nagar centre.

Panicle blight in litchi: The disease incidence of panicle blight in different orchards varied from 17.43-28.85% while most of the tree had disease severity (PDI) between 10.0-20.0%. The mean disease incidence of fruit blight on trees in farmers' orchard in Muzaffarpur, Bihar varied from 8.4-12.4% (mean 9.8%) in cv. 'Shahi' and 10.2-16.7% (mean 12.6%) in cv. 'China'

Leaf spot disease in litchi: Two different kinds of leaf spot disease were observed in nursery plants and bearing trees of litchi in orchard. The pathogens were identified as *Corynespora litchii* Matsush. and *Pestalotiopsis versicolor* Speg. Difenoconazole 25% EC, Copper Oxychloride 50% WP and Azoxystrobin 23% SC were found very effective in managing disease caused by *A. alternata.*

Alternaria leaf spot of lasoda: Jobner centre of AICRP on Arid Zone Fruits recommended two sprays of tebuconazole + trifloxystrobin (@ 0.10%) at an interval of 20 days from disease initiation during fruit bearing stage (April to June) as most effective in managing Alternaria leaf spot of lasoda with increased fruit yield and monetary return.

Etiology of emerging diseases in plantation crops: Etiology of emerging diseases such as dry spindle rot in coconut seedlings (*Lasiodiplodia theobromae* and *L. iranensis*), black spot disease of coconut (*Exserohilum rostratum*), cocoa seedling leaf spot (*Colletotrichum gloeosporioides*) and arecanut root decay (*Fusarium falciforme* (FSSC 3 + 4)) were established.

Novel mycelium inoculation technique: A rapid and novel mycelium inoculation technique for inducing *Ganoderma lucidum* infection in coconut and arecanut seedlings, which could be used for evaluating the resistance of coconut and arecanut cultivars to *Ganoderma lucidum,* was developed.

Native isolate against arecanut basal stem-rot: Identified and characterized a native plant growth promoting isolate of *Trichoderma asperellum* (isolate AT172) having antagonistic activity against arecanut basal stem-rot pathogen *G. lucidum.*

Leaf blight incidence in palm: Root feeding with propiconozole @ 5 ml in 100 ml of water at three months intervals during January, April, July and October reduced the leaf blight incidence by 27% after 36 months of treatment. This treatment also recorded the highest nut yield of 138 nuts/palm/year and the B:C ratio of 3.7 as against 97 nuts/palm/year in the untreated control.

Cashew leaf blight disease: The cashew leaf blight disease was identified for the first time in cashew. Based on cultural, microscopic, and molecular characterization the pathogen was confirmed as *Neopestalotiopsis clavispora*. This is the first confirmed report of cashew leaf blight disease (CLB) caused by *Neopestalotiopsis clavispora* from India.

Vegetable crops

Biopesticides and insecticides for management of sucking pests complex in brinjal: Spraying of Azadirachtin 300 ppm @ 5 ml/L in combination with *Lecanicillium lecanii* @ 2.5 g/L was found effective with 71.26, 52.58, 53.30 and 55.49% reduction in sucking pests population, viz. mites, whiteflies, aphids and leaf-hoppers, respectively and 28.16% increase in marketable yield with C:B ratio 1:4.23.

Integrated pest management (IPM) module in bitter gourd: IPM comprised seed treatment with imidacloprid, installation of yellow sticky traps, border crop with maize, spraying of Azadirachtin, thiamethoxam, imidacloprid, cyantraniliprole, Neem oil + *Lecanicillium lecanii* and neem oil + *Beauveria bassiana* from 20 DAS onwards to till 70 DAS at 10 days intervals each harboured lowest whiteflies population with maximum of 70.14% reduction over control (PROC). The number of predatory ladybird beetles and polyphagous spiders were also higher in this module. Furthermore, the highest healthy fruit yields were recorded from the integrated pest management module accompanied with maximum highest cost benefit ratio of 1:5.

Under AICRP (VC), treatment comprising of mulching, sequential spray of pyriproxyfen (5% EC) + fenpropathrin (15% EC), spiromesifen (22.9% SC), buprofezin (25% SC) and neem oil @ 10 days interval, recorded least average percent disease incidence (24.44%) against control (71.85%). Additionally, the same treatment recorded the highest average yield of 155.41q/ha over control (77.91q/ha). Also, the same treatment showed the highest C:B ratio of 1:1.95. Hence it can be recommended for the management of viral diseases in okra (Kashi Pragati) under Varanasi region.

Tuber crops

Management of plant parasitic nematodes in tapioca: Management of plant parasitic nematodes with the use of *Trichoderma harzianum* and *Pochonia chlamydosporia* enriched neem cake and organic manures and crop rotation with least preferred host plants like tapioca were demonstrated in the farmers' fields of Alappuzha district in Kerala.

Cassava stem and root-rot: The major pathogen associated with stem and root-rot of cassava in Kerala was identified as *Fusarium falciforme*. In the farmer's field, Carbendazim (0.05%) and Propineb (0.1%) showed highest reduction (100%) of the disease followed by a cassava biopesticide *Nanma* (0.7%), (88%), *Trichoderma asperellum* (75%). The cassava mosaic resistant var. SreeReksha released by ICAR-CTCRI did not exhibit any stem and root-rot symptom during 2021-2022.

Leaf and pseudo stem-rot in elephant foot yam: Association of species of *Phytophthora, Colletotrichum* and *Fusarium* with leaf and pseudo stem-rot in elephant foot yam was identified. The fungicides, hexaconazole 0.1% and propineb 0.1% were more effective in managing collar rot incidence in elephant foot yam than the present recommendation. Similarly, the fungicide, famoxadone+ cymoxanil (0.1%) exhibited least taro leaf blight incidence and highest yield.

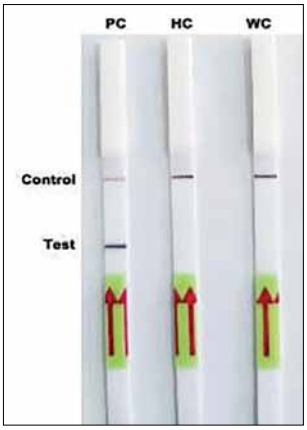
Management of taro leaf blight disease: Spraying with mancozeb + metalaxyl M @ 0.1% was the best to reduce the disease incidence (20-25%) and improved cormel yield (15-21% over control) and was recommended for the zones of Eastern Himalayan, Western Himalayan, middle Gangetic plains, Eastern plateau and hills, lower Gangetic plains, Southern plateau and hills, and in Islands.

Bio–intensive management of taro leaf blight: Dipping of cormels in *Trichoderma* amended (@ 5 g/kg) cow dung slurry + soil application of *Trichoderma* amended vermicompost @ 100 g/plant at the time of planting and later at the time of intercultural operations which was the second best treatment (10-14% higher yield over control) is recommended as technology for bio–intensive management of taro leaf blight in states declared as organic.

Spice crops

Development of RPA-lateral flow assay (RPA-LFA) assay for the detection of PYMoV infecting black pepper: The basic RPA method for the detection of piper yellow mottle virus in black pepper was standardized using TwistAmp DNA amplification kit. Different reaction conditions of the assay such as concentration of magnesium acetate, reaction incubation time and temperature were optimized. The RPA-LFA method was standardized for the on-site detection of the piper yellow mottle virus. The sensitivity of the assay was compared with RPA and PCR. Validation of the assay was performed along with PCR using field samples of black pepper representing different varieties and regions.

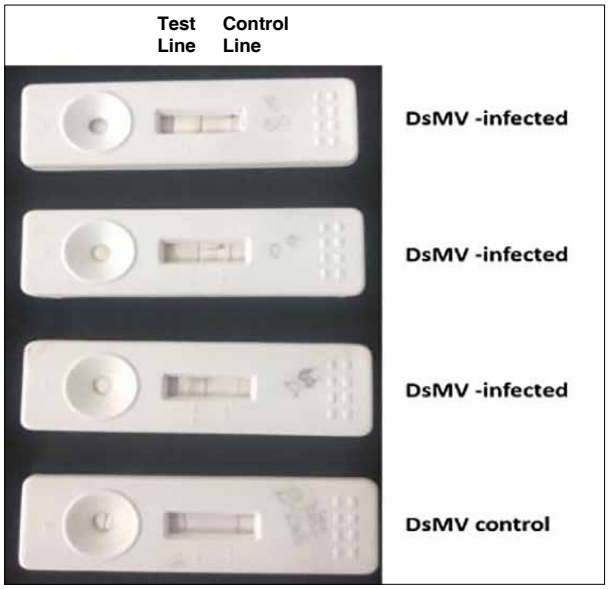
Recombinase polymerase amplification (RPA) protocol for detection of *Pythium* spp. and *R. pseudosolanacearum* infecting ginger: Singleplex and duplex recombinase polymerase amplification (RPA) assays were optimized for specific and sensitive detection of *Pythium* spp. and *Ralstonia pseudosolanacearum* from ginger rhizomes. The assays were 10-1000 times more sensitive than conventional PCR assays and were highly specific as they did not show any cross-amplification with other rhizome-borne pathogens of ginger. Validation test showed these pathogens could be successfully detected using crude DNA extracted from ginger



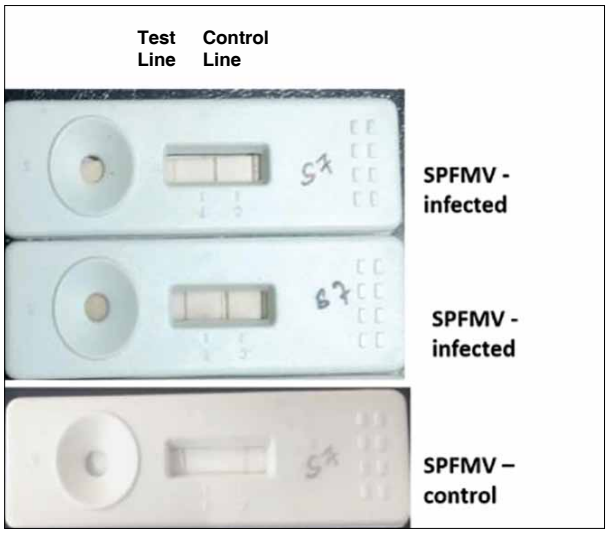
Detection of piper yellow mottle virus by recombinase polymerase amplification-lateral flow assay (RPA-LFA). PC: Infected plant, HC: Healthy plant, WC: Water control

rhizome samples collected from the field, storage, and market.

Detection of Dasheen mosaic virus (DsMV) and Sweet potato feathery mottle virus (SPFMV): The ICAR-CTCRI raised polyclonal antibobodies DSMV-IgG and SPFMV IgG were used to develop lateral flow devices to detect DSMV and SPFMV from field-infected elephant foot yam and sweet potato samples. Test line and control line lit up in samples infected with DsMV or SPFMV. The control line only was lighted up in uninfected control samples, indicating the device is working well to detect the infections.



Elephant foot yam (DsMV)



Sweet potato (SPFMV)

Sensitivity assay of *Mycogone perniciosa* and *Agaricus bisporus* to antifungal compounds: *Mycogone perniciosa,* which causes Wet Bubble Disease (WBD) in white button mushrooms (*A. bisporus*), is a worldwide problem in button mushroom cultivation. Given that, 19 selected antifungal compounds were used for sensitivity assays of *M. perniciosa* and *A. biporus* for crop protection agents under laboratory conditions. Mycelial growth inhibition assay was used to calculate the EC_{50} values of the treatments. The mean EC_{50} values of the selected crop protection agents on *M. perniciosa* ranged from 0.0146 to 0.6346 µg/ml. In addition, *A. bisporus* strain NBS 5 exhibited highly variable sensitivities (mean EC_{50} 0.0960 to 3.5397 µg/ml) to the tested treatments. Except, 1-Octen-3-ol, all other treatments showed good potential for the control of WBD *in vitro* sensitivity test. Safety factor (SF) value was calculated highest for BioRub (69.95) whereas, it was found least in 1-Octen-3-ol (0.23).

Marker free late blight resistant transgenic line KJ66: The mendelian pattern of segregation of RB event SP951 in Kufri Jyoti progenies revealed marker and plasmid backbone free KJ66 line in Kufri Jyoti background. The line has been selected to conduct the Biosafety research trial for evaluating the field resistance to late blight disease. The event KatSP951 was crossed with cultivar Kufri Jyoti and approximately 1,000 hybrid true potato seed were obtained and progeny F1 plants

A New Bacterium Identified for Management of Cumin Blight

After rigorous screening, a bacterium was identified and tested against cumin blight disease both *in vitro* and *in vivo*. *In vitro*, the bacterium showed 90% pathogen mycelium inhibition whereas in natural conditions, the bacterium reduced 59% disease intensity when applied three foliar sprays @ 20% of stock formulation made with the bacterium population of 9.7x10-5. Further, the identified bacterium was confirmed as *Bacillus amyloliquefaciens* from ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi. There are several reports that this bacterium is beneficial and has been applied as a bio-control agent in other crops including maize. The *B. amyloliquefaciens* bacterium based technology in the future may be a breakthrough in biological control of cumin blight disease at field level that can break the hurdle of residual toxicity in cumin and provide quality produce for export on one hand and may raise the income of farmers on other hand.

Comparison of disease control (Treated and untreated cumin plant)

were screened for the presence of the Rpi-blb1 and nptII-containing inserts. Progeny line KJ66 was identified as containing only the Rpi-blb1 insert on chromosome 4.

Prototype of a remote operated unmanned ground (UGV) vehicle: It was designed and developed at ICAR-CPRI RS, Jalandhar for spraying of agrochemicals like pesticides, weedicides, liquid fertilizers etc. on potato crop.

Long term storage of fungal cultures: Sodium alginate based bead formulation of fungal mycelia and conidia for long term storage of fungal cultures were developed. Ready to use Bordeaux paste and solid formulations effective against *Phytophthora* spp. with a shelf life of 60 days was developed.

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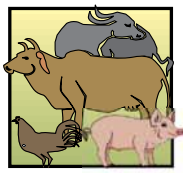


7. Livestock Management

Nutrition

Fodder production using camel dung vermi-compost was evaluated. Use of vermi-compost improved growth and yield of sorghum and oat fodder that was evident from the improvement in plant height and weight of plant.

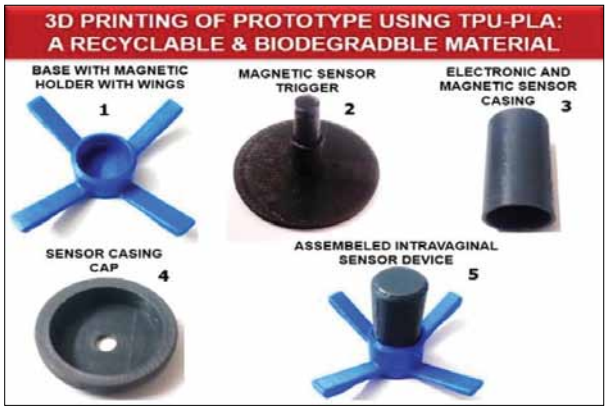
Buffalo Calves Produced from Semen of the Cloned Bulls

Twenty female buffaloes were inseminated with the semen of two cloned bulls. Following insemination, a 65% conception rate was achieved, which is normal in buffaloes. Thirteen healthy calves (seven males and six females) were produced. These calves are physiologically normal, growing well and healthy. The technology will lead to future sustainable milk production in the country.

Calves produced from semen of cloned bulls namely Swarn and Rajat (August-December 2021)

Physiology

Prototype of intra-vaginal wireless sensor device: Prototype of intra-vaginal wireless sensor device was developed for remote monitoring of calving process in dairy cows. This could help in predicting the calving time in cattle.



Ready to use semen extender for buffalo semen: Semen dilution to 12 million sperm/dose did not affect the conception rate after AI in buffalo. Therefore, LDL-based extender could be used containing a smaller number of sperms to maximize the use of elite bulls.

Livestock Protection

Disease Informatics

The National Animal Disease Referral Expert System v2 (NADRESv2), a dynamic geographic information and remote sensing-enabled expert system, developed and maintained by ICAR-NIVEDI was updated in the NADRES database, and a total of 5655 predictions for major livestock diseases of varied levels of risk were predicted and reports were communicated to State Animal Husbandry Departments (including NADEN centers), government stakeholders and Department of Animal Husbandry and Dairying (DAHD), GoI, in the form of risk maps, bulletins, and post-prediction maps for necessary preparedness. The risk communication through SMSs to farmers was also continued. Novel initiatives like Farmers Empowerment through IT, Farmer Registration and Unified Beneficiary Information System (FRUITS), a web application of NIC, Govt of Karnataka, and a total of 12,095,848 SMS alerts were sent to farmers in Karnataka for different animal diseases (anthrax, babesiosis, black quarter, bluetongue, FMD, theileriosis).

Nation-wide sampling plans for sero-surveillance and sero-monitoring of foot and mouth disease (FMD), brucellosis, *Peste des Petits Ruminants* (PPR) and classical swine fever (CSF) for each state/UTs of the country were formulated and provided to DAHD, GoI, for strengthening the surveillance system. The district-wise sampling plans for sero-surveillance of 14 zoonotic diseases were provided to evaluate the status of these disease in the country.

Sero-epidemiology: Screening of serum samples (32,257) for important livestock diseases from different animal species submitted by various NADEN units and State Animal Husbandry Departments was carried out. Of the total samples screened, 1625 buffalo serum samples from 9 states (Sikkim, Mizoram, Chhattisgarh, Uttar Pradesh, Himachal Pradesh, Odisha, Kerala, Tamil Nadu, and Uttarakhand) 3.63% were positive for brucellosis. The sero-diagnostic services were provided for Infectious bovine rhinotracheitis (IBR), trypanosomiasis and pasteurellosis with 28.9%, 49% and 4.5% positivity, respectively, in ruminants. A total of 795 samples comprising serum, urine, and blood (human-468, goat-81, cattle-73 and buffalo-173) from Karnataka, Maharashtra, and Tamil Nadu were tested by microscopic agglutination test (MAT), of which, 56 (human- 36, goat- 3, cattle- 9 and buffalo-8) serum samples showed positive reactivity against different Leptospira serovars.

Post vaccination sero-monitoring: Brucella post

vaccination sero-monitoring is one of the major activities to evaluate the impact of the control program. Towards this, a total of 14,611 sera collected from different states were screened, of which, 64.45% were positive for anti-brucella antibodies.

Foot and mouth disease

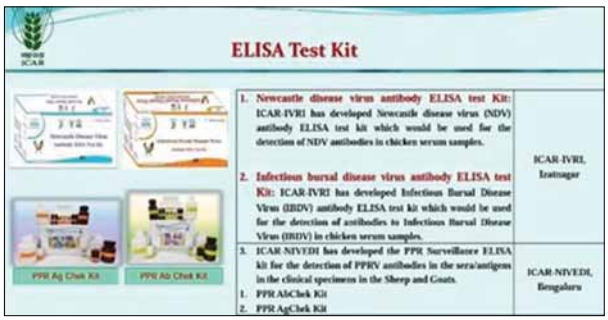
Sero-surveillance and sero-monitoring: Under FMD sero-surveillance, 98,185 bovine serum samples from around the country were analyzed to determine the prevalence of FMDV circulation/ recent past infection. Overall seropositivity was 16.6% which is higher than the previous year's average of 13.8%. In addition, 14,061 serum samples from small ruminants and pigs were also screened. A total of 30,137 serum samples were examined to assess the efficiency of immunization. In addition, 8,183 serum samples received from various breeding bull stations and surrounding villages were also tested to assess the protection level. The institute provided the state FMD centers with three main test kits (3AB3 indirect DIVA ELISA for 1,75,583 samples, Solid Phase Competitive ELISA (SPCE) for 1,56,778 samples, and Sandwich ELISA for 3893 samples).

Molecular epidemiology: A total of 2,824 clinical samples were analyzed for serotype identification in 378 FMD outbreaks. During 2021, all three FMD virus serotypes were documented, with serotype O leading the outbreak scenario followed by serotype A. Overall, the disease incidences have increased compared to previous year. A total of 113 FMD virus isolates (102 O, 10 A and 1 Asia 1) revived in BHK-21 cell system were added to the National Repository of FMD virus maintained at International Centre for FMD, Bhubaneswar and Mukteswar Laboratory. At present, the National FMD virus repository holds a total of 2,391 isolates (O-1676, A-333, C-15 and Asia 1-367).

The capsid coding region (P1/VP1) sequences of 68 FMD viral strains were inferred and added to the sequencing database of Indian FMD viruses (54 serotype O, 13 serotype A and 1 serotype Asia1). In serotype O, dominance of the O/ME-SA/Ind2001e and O/ME-SA/2018 lineages was discovered, as was the advent of G-18/non-deletion/2019 lineage in serotype A and Group IX in Asia1.

Diagnostics developed

- The PPR Ab Check kit for the detection of PPR virus nucleocapsid protein antibodies in the serum samples and PPR Ag Check kit for the detection of PPR virus in clinical specimens of sheep and goats, were developed.
- Recombinant nucleocapsid protein based indirect ELISA kit for detection of Anti SARS-CoV-antibodies in canines (CAN-CoV-2 iELISA kit) and Multi recombinant proteins based ELISA Kit for diagnosis of *Trypanosoma evansi* infection in animals were developed.
- TaqMan-probe-based real-time RT-PCR assays (RT-qPCR) for pan-serotype detection of FMDV in India was developed, which can be used in a high-throughput manner for rapid analyses of clinical samples during active virus surveillance procedures.
- *Development of a recombinase polymerase assay for detection of African swine fever virus in pigs*: A recombinase polymerase assay (RPA) was developed for detection of ASF virus targeting partial B646L gene (478 bp) encoding p72 protein of ASFV. Analytical sensitivity of the assay was estimated to be up to 13 copies of viral RNA.
- *Multiplex PCR to differentiate Mycobacterium tuberculosis complex species*: A multiplex PCR was developed that can distinctly differentiate *Mycobacterium tuberculosis* complex (MTBC) species circulating in animal population in India, viz. *M. orygis*, *M. bovis*, *M. caprae* and *M. tuberculosis*. Further, *M. bovis* species can also be differentiated from the vaccine strains of *M. bovis* BCG by this PCR.
- *Rapid colorimetric assay for detection of the extended spectrum β-lactamase producing bacteria*: An easy and rapid modified colorimetric assay (mCA) was developed for detection of the extended spectrum β-lactamase (ESBL) producing bacteria.
- *Lateral flow assays (LFAs) for Canine Distemper (CD)*: Lateral flow assays (LFAs) for detection of CD virus antigen and antibody were developed using the in-house developed monoclonal antibody (mAb) against the nucleoprotein (N) of CDV (Dog)/Bly/Ind/2018 isolate. The assay developed for viral antigen was able to detect a virus sample of $10^{6.5}$ TCID/ml titre. The same strip was assessed for its potential of antibody detection in competitive mode. The detection limit for antibody detection by the LFA was 1:32. The diagnostic sensitivity (Dsn) and specificity (Dsp) for antigen detection were 66.6% and 100%, respectively. For antibody detection, Dsn and Dsp were 80.4% and 94.4%, respectively.



ABrC-ELISA (PPR Ab Check kit and PPR Ag Chek kit) Kit

Vaccines

Ancovax: An inactivated vaccine to prevent SARS-CoV2 infection in animals was developed.

Homologous live-attenuated vaccine, Lumpi-ProVac^{Ind} against LSD: A homologous live-attenuated LSD vaccine, named Lumpi-ProVac^{Ind} was developed.

The virus used for developing the vaccine was isolated from skin scab collected from a naturally LSDV-infected cattle in 2019 (Kenyan type LSDV strain). The vaccine has been found to be safe in cattle and buffaloes of all age groups including lactating/ pregnant animals and bulls. Further, LSDV/India/2022 is completely neutralized by sera derived from LSDV/India/2019 and vice versa, and therefore, Lumpi-ProVac^{Ind} can be used to replace the existing goatpox vaccination practice against LSD in cattle in India. The vaccine technology has been commercialized.

Inactivated low pathogenic avian influenza (H9N2) vaccine for chickens: The inactivated low pathogenic avian influenza (H9N2) vaccine for chickens was developed for the prevention and control of H9N2 avian influenza virus infection in chickens. The candidate vaccine strain [A/chicken/India/22213/2006 (H9N2)] was selected on the basis of phylogenetic and antigenic analysis of H9N2 viruses isolated from India during 2003 to 2017. The safety, potency and efficacy of the vaccine were ascertained. It provides protective immunity in chickens for six months following vaccination and covers all the antigenically divergent strains of H9N2 low pathogenic avian influenza virus currently circulating in India. This is the first indigenously developed low pathogenic avian influenza (H9N2) vaccine in India and the vaccine will help in prevention and control of the infections with H9N2 virus in chickens, specifically in layer and breeder chickens thereby reducing production losses and improving the livelihood of poultry farmers/ industry.

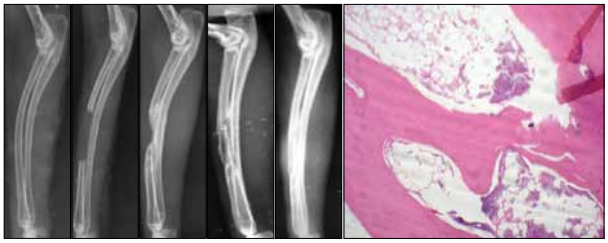
Inactivated low pathogenic avian influenza H9N2 vaccine

Thermostable serotype O vaccine for FMD: Foot-and-mouth disease (FMD) vaccine virus serotype O, that was generated through introduction of mutation (Y2098F) in the genome, showed increased thermostability. Immune response against the thermostable vaccine candidate was studied for 12 months duration in cattle with comparison to its parent trivalent vaccine formulation. The thermostable vaccine group exhibited higher immune response.

Negative-marker mutant FMDV serotype O candidate: A negative-marker mutant FMDV serotype O with partial deletion in non-structural protein 3A was generated. The inactivated candidate negative marker virus induced enhanced immune response in guinea pigs apart from facilitating DIVA compliance. A competitive ELISA was also developed as companion test for the negative-marker vaccine.

Therapeutics

Mesenchymal stem cells for skin wound, bone and nerve healing in animal models: Mesenchymal stem cells (MSCs) with or without egg shell membrane, bioactive collagen gel, collagen powder, platelet rich plasma, and MSC laden nano-scaffolds of hydroxyapatite and multiwalled carbon nanotubes were evaluated for skin wound, bone and nerve healing in animal models, and showed promising results.



Extensive new bone formation in the bone defect site in stem cell laden nano-scaffold groups

Nimesulide safety testing in Himalayan griffons: Healthy wild-captured Himalayan griffons were selected for experiment. It was found that the NSAID nimesulide is toxic to vultures.

ROCK1/MLC2 inhibition induces decay of viral mRNA in BPXV infected cells: Activation of ROCK1/ myosin light chain (MLC2) signaling pathway was observed in buffalopox virus (BPXV) infected Vero cells. ROCK1 depletion by siRNA and specific small molecule chemical inhibitors (Thiazovivin and Y27632) resulted in a reduced BPXV replication, as evidenced by reductions in viral mRNA/protein synthesis, genome copy numbers and progeny virus particles. In conclusion, ROCK1/MLC2 cell signaling pathway facilitates BPXV replication by preventing viral mRNA decay and that the inhibitors targeting this pathway may have novel therapeutic effects against buffalopox.

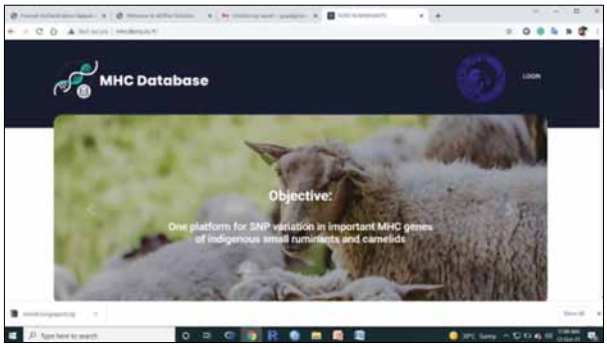
Resistance evolution against host-directed antiviral agents: Buffalopox virus switches to use p38-ϒ under long-term selective pressure of an inhibitor targeting p38-α. Host-dependency factors have increasingly been targeted to minimize antiviral drug resistance. It was demonstrated that inhibition of p38 mitogen activated protein kinase (MAPK, a cellular protein) suppresses buffalopox virus (BPXV) protein synthesis by targeting p38-MNK1-eIF4E signaling pathway. In order to provide insights into the evolution of drug resistance, we selected resistant mutants by long-term sequential passages (P; n=60) in the presence of p38 inhibitor (SB239063). The P60-SB239063 virus exhibited significant resistance to SB239063 as compared to the P60-control virus. This is a rare evidence, wherein a virus was shown to bypass the dependency on a critical cellular factor under selective pressure of a drug.

Sheep

Generation of indigenous online "Immuno-

Polymorphism Database: An online database management system named MHC Database was created (http://www.mhcdbms.in/) to allow easy access and use of immune polymorphism data. This system also allows user to upload as well as download the indigenous *Ovar* MHC allelic database for sheep breeds in *FASTA* format. The database also allows user from goat and camels to use the database for uploading or downloading the sequences. Sequences can be submitted and retrieved in Fasta format. Sequences are pooled for a breed together.

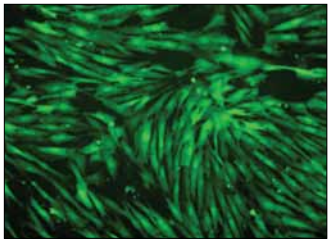
MHC database for sheep, goat and camels (www.mhcdbms.in)



Developed at NDRI and located at NDRI server

Goat

Human erythropoietin (hepo) expressed in goat somatic cells by CRISPR/Cas9 mediated knocking-in of HEPO gene: Mammary epithelial cells derived from goat mammary glands under *in vitro* conditions are an attractive alternative for the production of secretory recombinant hEPO protein. CRISPR/Cas9 mediated genome editing was carried out to express human erythropoietin in goat somatic cells. Goat mammary epithelial cells were genetically modified for the production of recombinant hEPO in a conditioned medium.



CRISPR/CAS9 mediated knock-in of human erythropoietin gene in the goat fibroblast cells. The transgenic goat fetal fibroblast cells expressing hEPO gene fused with green fluorescent protein (GFP) gene

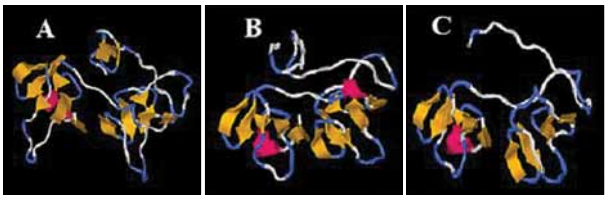
Equine

Glanders surveillance: ICAR-NRCE, Hisar is actively involved in glanders surveillance, providing diagnostic support, capacity building of state diagnostic laboratories/ RDDLs. For rapid and efficient execution of surveillance activities, Hcp1 ELISA kit developed by NRCE is being used for glanders diagnosis. A total of 16,431 equine sera received from 19 states under glanders surveillance programme were tested. Out of these, 106 glanders positive cases were recorded from 12 states.

Surveillance and monitoring of equine infectious diseases: A total of 1,737 equine serum samples from 8 states were tested for equine infectious anaemia (EIA), equine influenza (EI), Equine Herpes Virus-1 (EHV-1), Japanese Encephalitis/ West Nile Virus (JEV/WNV), *Trypanosoma evansi* (Trypanosomosis), piroplasmosis, *Salmonella Abortus equi* and brucellosis. Highest sero-prevalence was observed for equine *piroplasmosis* (38.40%) followed by EHV-1 (7.80%), JE/WNV (7.40%), and *Trypanosoma evansi* (2.15%). A total of 9,254 samples were tested under contractual diagnostic services with earning of ₹69.65 lakhs as revenue.

High throughput deep proteomic analysis of seminal plasma from stallions with contrasting semen quality: Seminal plasma proteins and pathways associated with sperm motility have not been elucidated in stallions. Stallion seminal plasma proteins were profiled and the proteins and pathways associated with sperm motility were identified. A total of 1,687 proteins in stallion seminal plasma, of which, 1,627 and 1,496 proteins expressed in high- (HM) and low- motile (LM) sperm of stallions, respectively, were identified. Gene ontology and Kyoto Encyclopedia of Genes and Genomes (KEGG) analysis revealed dysregulation of the important proteins related to mitochondrial function, acrosome, and sperm cytoskeleton in the seminal plasma of stallions producing ejaculates with low sperm motility. High abundance of peroxiredoxins and low abundance of seminal Chaperonin Containing TCP1 Complex (CCT) complex and Annexins indicate dysregulated oxidative metabolism, which might be the underlying etiology for poor sperm motility in LM group stallions.

Purification, molecular characterization and ligand binding properties of the major donkey seminal plasma protein DSP-1: A major FnII protein was identified and isolated from donkey (*Equus hemionus*) seminal plasma, which was referred as Donkey Seminal Plasma protein-1 (DSP-1). High-resolution LC-MS analysis indicated that the protein was heterogeneously glycosylated. From the foregoing, it is quite clear that the major FnII proteins of mammalian seminal plasma play crucial roles not only in priming spermatozoa for fertilization, but also in protecting other seminal plasma proteins from misfolding/inactivation as exemplified by the bovine protein, PDC-109 and the equine protein, HSP-1/2.



Three-dimensional structures of DSP-1 (A), HSP-1 (B) and PDC-109 (C) generated by I-TASSER server

Pig

African swine fever (ASF): Total 456 out of 861 porcine samples received from 14 states [Bihar (88 out of 107), Sikkim (28 out of 65), Uttar Pradesh (31 out of 60), Uttarakhand (77 out of 163), Delhi (12 out of 14),

Kerala (9 out of 29), Mizoram (24 out of 24), Karnataka (11 out of 15), Punjab (46 out of 144), Jharkhand (16 out of 36), Madhya Pradesh (49 out of 90), Haryana (59 out of 93), Goa (6 out of 18) and Odissa (0 out of 3)] were found to be positive for ASF by real time PCR.

Porcine reproductive and respiratory syndrome (PRRS): Five out of 216 porcine samples received from Sikkim (5 out of 167) and Madhya Pradesh (0 out of 49) were positive for PRRSV genome by RT-PCR.

Sero-prevalence and molecular epidemiology of important porcine viral diseases in pigs in NER: Total 211 serum samples were screened against CSFV, ASFV, PCV-2, PRRS and JEV from Assam, Meghalaya and Manipur. Sample positive for JEV (61) in serum and PCV-2 positive in 12 samples. Total 79 samples (48 tissue and 31 blood samples) were analysed and 4 were positive for PCV2, 2 for PRRS, 2 for CSVF and 2 for ASFV.

Poultry

Avian influenza: A total of 34,714 samples (5,757 sera and 28,957 morbid) received from 18 states/UTs were tested against avian influenza, of which 245 morbid samples from Bihar, Kerala, Maharashtra and Rajasthan were positive for H5N1 virus, 1 sample from Madhya Pradesh was positive for H5N8 virus and 352 samples from Chhattisgarh, Gujarat, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra and Rajasthan were positive for H9N2 low pathogenic avian influenza virus. A total of 142 sera samples from Kerala were positive for antibodies to H5 subtype avian influenza virus and 30 serum samples from Chandigarh, Chhattisgarh, Haryana, Kerala, Punjab and Uttar Pradesh were positive for antibodies to H9 subtype avian influenza virus.

Transgenic chicken as bioreactor for production of therapeutics: Transgenic chickens were produced through sperm mediated gene transfer (SMGT) method with an efficiency of 5.4%. In the transgenic birds, human interferon alpha 2b gene was introduced at the germ line stage for which ovalbumin promoter based transgenic cassette was developed, transferred and integrated in the chicken genome. Up to 45 weeks of age, transgenic hens laid 132 eggs with an average content of 30-40 mg of interferon alpha 2b protein in each egg.

Yak

Characterization of colostrum of native cattle and yak of high-altitude region: Metabolomic fingerprints of milk colostrum were studied between two native bovines, viz. Ladakhi cows (LAC) and Ladakhi yak (LAY) adapted to the high altitude of Leh-Ladakh, in comparison to Sahiwal (SAC). The majority of the metabolites were elevated immediately after calving (0 day) as compared to 2nd and 4th days in LAC, LAY as well as in SAC. Multivariate analysis demonstrated distinct clustering of colostrum metabolome in the subsequent day's post-parturition. Across all the breeds, the antioxidant content was maximum in 0-day samples and subsequently declined in 2 and 4 days post-calving samples. Along with antioxidants, the total available minerals were analyzed. Most of the minerals especially, Zn, Fe, Cu, Mg were high in yak colostrum in comparison to Ladakhi and Sahiwal cows.

Lumpy skin disease (LSD): Samples from LSD suspected outbreaks in 20 States/UTs of the country were tested to identify laboratory confirmed cases of LSDV infection for undertaking prevention and control measures against LSD in India. A total 2,456 bovine (cattle and buffalo) samples were tested, of which 1,156 cattle samples from 19 States/UTs (Gujarat, Madhya Pradesh, Uttar Pradesh, Haryana, Delhi, Andaman & Nicobar Islands, West Bengal, Jammu & Kashmir, Himachal Pradesh, Punjab, Rajasthan, Maharashtra, Goa, Andhra Pradesh, Chandigarh, Bihar, Jharkhand, Tamil Nadu and Chhattisgarh) tested positive for LSDV.

Emergence of exotic and emerging animal diseases

First whole genome analysis of Indian African swine fever viruses reveals potential genetic determinants to differentiate closely related ASFV circulating in Asia: After emergence, ASF has been confirmed in 19 states across the country and has caused heavy mortality and economic losses.

Whole genome of two ASF viruses isolated from domestic pigs during first outbreaks in Assam and Arunachal Pradesh were sequenced and analysed. The sizes of assembled complete genome of ASFV from Assam (IND/AS/SD-02/2020) and Arunachal Pradesh (IND/AR/SD-61/2020) isolates were 190,517 bp and 190,572 bp, respectively. The complete genome sequences were annotated to 219 putative genes as compared to 194 genes in ASFV Georgia/2007. Both sequences of Indian ASFVs had insertion of one extra TRS (TATATAGGAA) in the intergenic region between I73R and I329L and a few unique mutations were observed in MGF 369-11L, MGF 505-4R, K205R and B263R genes.

Global alignment of the complete genome sequences showed nucleotide identity of 99.96% amongst the two Indian isolates (IND/AS/SD-02/2020 and IND/AR/SD-61/2020). With other genotype-2 ASFV such as Georgia/2007 and Wuhan 2019-1, the nucleotide identity was 99.73% to 99.75% and 99.95% to 99.98%, respectively. The Indian isolates had unique SNP with predicted amino acid transitions viz. E294G in MGF 369-11L, K225E in MGF 505-4R, R188K in K205R and V168A in B263R genes. Complete genome based phylodendrogram of Indian ASFV isolates with 33 additional ASFV sequences showed their clustering under clade 2.2.2 with other p72-genotype-II ASFV reported from Tanzania, Georgia, China, Vietnam, Poland, Ukraine, East Timor leste, etc. Phylogenetically, concatenated nucleotide sequence of 14 open reading frames (ORF) with single nucleotide polymorphism of Indian isolates grouped separately with other ASFVs from Asia. Our results showed the importance of the 14 ORFs in understanding the evolution of ASFV in Asian countries and their divergence from prototype

Food-grade Meat Decontaminant Spray

A food-grade meat decontaminant spray was developed by using the extracts of Ashwagandha roots and Guava leaf along with permissible antimicrobial substances. This spray could reduce the microbial load many folds in retail fresh chicken. The spray is more effective as compared to commercial products and showed its antimicrobial activity for 60 days, if stored at 4±1°C.

ASFV Georgia/2007.

Emergence of NI-2490 like LSDV wild-type strains in India (Implications on diagnosis and differentiation of LSDV strains): The genetic analyses based on 1446-nt full-length GPCR (LSDV011) sequences of lumpy skin disease virus (LSDV) strains from 2019, 2020 and 2021 LSD outbreaks in India revealed that they possess a 12-nucleotide insertion in GPCR gene, similar to that found for the historical wild-type strains from Kenya (NI-2490) and in currently circulating wild-type strains from Bangladesh, Nepal and Myanmar and in all currently used LSDV homologous live-attenuated vaccine strains. In contrast, predominantly prevalent contemporary LSDV wild-type strains circulating globally (Africa, Middle East, Central Asia and Eastern Europe) have a 12-nucleotide deletion. As the currently used GPCR assay is based on the deletion of 12-nt GPCR gene of LSDV wild-type strains, prevalence of LSDV wild-type strains with 12-nt insertion in India suggests limitations of the current GPCR based assay for differentiation between LSDV wild-type and vaccine strains.These findings highlight the need for using multi-target based assays to correctly identify and discriminate between LSDV wild-type, vaccine and recombinant strains.

Whole genome sequencing and identification of two different sub groups of bovine coronavirus in India: Whole genomes of 12 bovine coronaviruses isolated from cow (3) and buffalo (9) nasal and faecal samples collected in 2020-21 were sequenced. Phylogenetic analysis of the whole genomes with the global bovine coronavirus whole genome data reveals that 9 of the viruses cluster with the classical bovine coronaviruses in subgroup GIa that has isolates from all over the world like China, USA and Germany. Three other viruses cluster with the GIb subgroup, which has majorly the isolates of France in 2017. This is indicative of co-circulation of two different subgroups and also suggests of multiple introductions.

Exploitation of nanoparticle conjugated phytochemicals against multi-drug resistant pathogens: The phytochemicals (thymol and cinnamaldehyde) conjugated silver nanoparticles (AgNPs) were tested for their efficacy against Enteroaggregative *Escherichia coli* (EAEC) and non-typhoidal *Salmonella*. Assays revealed the antimicrobial activity of the encapsulated compounds (EAgC and EAgT) with a 2-fold increase when compared to the conjugated compounds (AgC and AgT). Besides, EAgC and EAgT were variably stable, when exposed to various physicochemical conditions (high-end temperatures, protease enzymes, cationic salts, and *p*H). All the tested encapsulated leads appeared to be safe (secondary cell line-based MTT assay and commensal gut lactobacilli). *In vivo* antimicrobial efficacy of the identified leads exhibited increased survival rates and declined bacterial counts. The bacterial counts (*E. coli* and *Salmonella*) reduced significantly. Improved feed conversion ratio (FCR) was observed.

❑

IVRI-Online Veterinary Clinic Portal

The IVRI-Online Veterinary Clinic portal was released during the X Convocation of IVRI.

Plastic Based Two-tier Housing System

Climate friendly shelter is imperative for optimal productivity of the animals. Animals housed in twotier housing system had significantly higher average daily weight gain; owing to more hygienic environment contributing to fewer incidences of diarrhoea and respiratory problems as kids had less contact with faecal materials and chance of infection was lower.

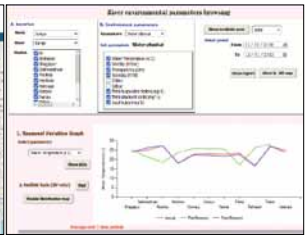
Bakri Garbhadhan Setu

A mobile App on 'Artificial insemination in goats' was developed. This App provides the videos related to various aspects of AI in goats through which a simple or less educated stakeholder can easily understand the different aspects of AI.

8. Fisheries Management

Online data-portal for fisheries resource assessment: Developed a Web-GIS application for location-specific riverine fisheries management. It provides an interactive and user-friendly interface for customized information browsing and report generation to understand system dynamics. It contains environmental data of 300 sampling stations covering 20 major rivers of India. The developed portal also allows users to search, visualize, understand and analyze the customized spatio-temporal for the assessment and planning of the system. The portal's database and customized reports will facilitate various researchers, planners and policymakers to make judicious planning/strategies for the betterment of fisheries resources.

Visualization of spatio-temporal data in GIS platform



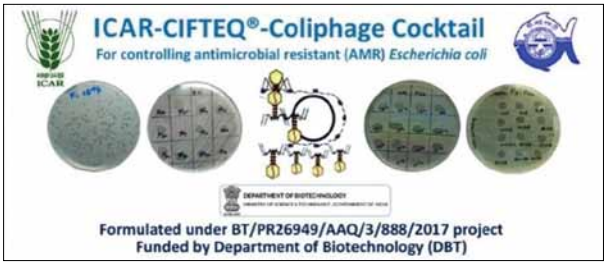
Environmental parameter search window

Detection of mud crab reo virus: Mud crab, *Scylla serrata,* is an economically important crustacean species which is also being cultured. Mud Crab Reo Virus (MCRV) is an emerging viral pathogen in mud crab culture. On RT-PCR screening, MCRV were detected in gills and hepatopancreatic tissues. TEM analysis revealed the virus particles in hepatopancreas and histopathological lesions were observed in gills and hepatopancreas. As mud crab fattening and farming activities mainly depend on wild seed collection, hence, it is advisable to screen the animals for MCRV by RT-PCR before stocking.

MCRV infected *S. serrata* displaying grey colour shell discolouration

Point-of-care diagnostic (POD) methods to detect cyprinid herpesvirus 2 in goldfish: Herpesviral haematopoietic necrosis disease (HVHND) is caused by cyprinid herpesvirus 2 (CyHV-2), which causes severe mortality in goldfish, *Carassius auratus;* crucian carp, *Carassius carassius*, and gibel/prussian carp, *Carassius gibelio*. A rapid and sensitive RPA (recombinase polymerase amplification) assay, coupled with lateral flow dipsticks (LFD) was developed by designing specialized RPA primer, LFA primers and probes. Among the various visualization methods for RPA amplicons, lateral flow dipstick (LFD) assay is better suited for point-of-care (POC) testing as it facilitates analysis of results with the naked eye. This assay could achieve sensitive diagnosis of CyHV-2 in goldfish within 20 min at 36°C with the satisfactory detection limit of 10^2 gene copies per reaction. This is the first report wherein major capsid protein (MCP) of CyHV-2 was targeted for RPA-LFD assay development. The assay did not show any cross reactivity with other viral pathogens like cyprinid herpesvirus 3 (CyHV-3), spring viraemia of carp virus (SVCV), infectious spleen and kidney necrosis virus (ISKNV) and viral nervous necrosis virus (VNNV). Furthermore, screening of CyHV-2 in CyHV-2 infected goldfish did not yield any false positive/negative results. In short, the RPA-LFD assay developed in this study presents a simple, rapid and sensitive method for point-of-care diagnosis of CyHV-2, especially under resource limited conditions.

Potential pathway for spread of tilapia lake virus: The recent global spread of tilapia lake virus (TiLV) is speculated to be due to transboundary movement of infected fish and, in this, extensive trade of ornamental cichlids can be a potential pathway for the spread of TiLV. Against this background, under the reporting period, the susceptibility of three cichlid (angelfish, firemouth cichlid and parrotfish) and two non-cichlid (three spot gourami and goldfish) ornamental fishes to experimental infection with TiLV was evaluated. The infection status was evaluated through quantitative real-time PCR and cell culture-based virus isolation. The study revealed the susceptibility of angelfish to TiLV and inapparent infection in firemouth cichlid indicating the asymptomatic carrier potential of the species. However, parrotfish, three spot gourami and goldfish showed resistance to experimental infection with TiLV. The results indicated the existence of wide host-range of TiLV in non-tilapine ornamental fishes and the potential



role of these fish in the epidemiology of TiLV disease.

Further, fish species susceptibility of Tilapia Lake Virus (TiLV) was studied by the co-habitational challenge method on different barbs and cichlids. The results indicated that *Puntius ticto* and *Amatitlania nigrofasciata* (Convict cichlid) were susceptible; whereas, *P. gonionotus, P. conchonius* and five different cichlids (*Pseudotropheus socolofi*, *Labidochromis caeruleus*, *Melanochromis auratus*, *Labidochromis chisumulae* and *Maylandiaes therae*) were resistant to TiLV infection.

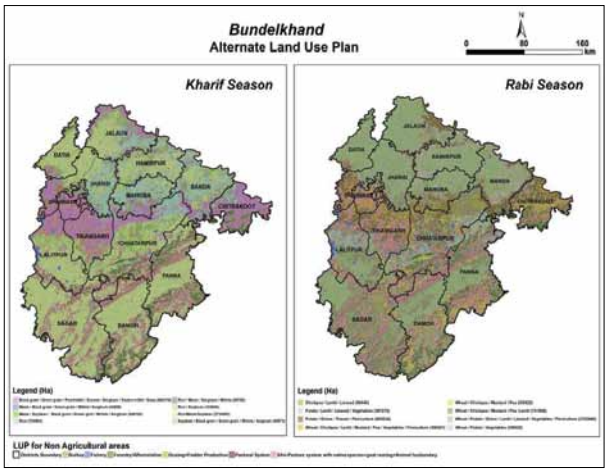
Coliphage cocktail for controlling antimicrobial resistant *E. coli*: Developed a Coliphage cocktail for controlling antimicrobial resistant (AMR) *Escherichia coli*, containing 10 coliphages, selected based on their broad host range, varied location and their ability to lyse AMR *E. coli*. The Coliphage cocktail has a phage titer of ~10^{12} to 10^{14} pfu/ml and can be used for the control of *E. coli* and AMR *E. coli* on food contact surfaces. The Coliphage cocktail can be stored under chilled conditions (<4° C) condition for a minimum period of 3 months. ❑

9. Soil and Water Productivity

The special thrust was given on micro level agricultural land-use planning, soil and water conservation, water-harvesting storage and groundwater recharge, improving water-productivity and nutrient use efficiencies, integrated nutrient management, resource conservation technologies, chemical-free agriculture, integrated farming system including agroforestry, waste- water utilization, dryland, hill and coastal agriculture, weed management, precision agriculture, climate- resilient agriculture and abiotic-stress management across the states/UTs of India.

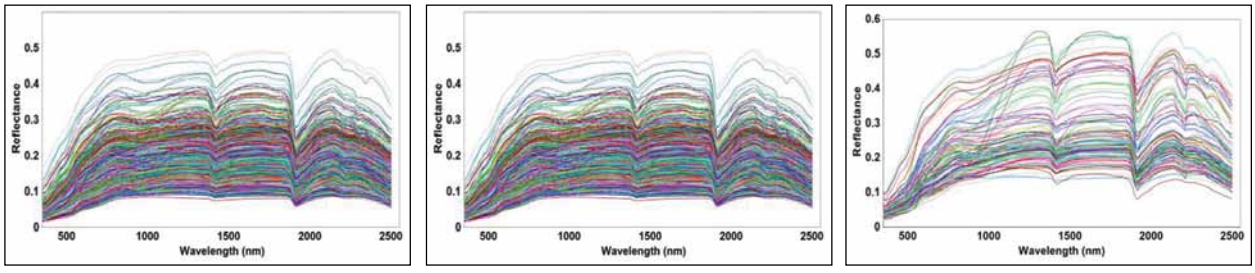
Land-resource inventory of Bundelkhand region: Agricultural land-use planning, based on the soil characteristics, climate, water availability/irrigation facilities and socio-economic imperatives is essential to utilize the full potential of land and water resources choosing the right crop/cropping system suitable for the region. The ICAR-NBSS&LUP, Nagpur had developed land-resource inventory (1:10,000 scale) for Bundelkhand for sustainable land use.

Hyperspectral characterization of soils and development of soil spectral library: A new initiative was taken to build a digital/spectral signature library of the soils of India for quick and inexpensive acquisition of surface soil properties. Reflectance spectra of 3,186 soil samples collected from Project on Climate Resilient Agriculture (PoCRA) districts and Vidarbha region of Maharashtra; Morena, Datia, Sagar and Damuah districts of Madhya Pradesh, and Surat, Valsad, Bharuch and Kachchh districts of Gujarat was studied. Predictive modeling of different soil properties (analysed by wet chemistry) was carried out with the help of spectral signatures. The measured values of soil properties (pH, EC, soil-organic carbon, sand and clay content, $CaCO_3$ content) correlated well with the predicted values.



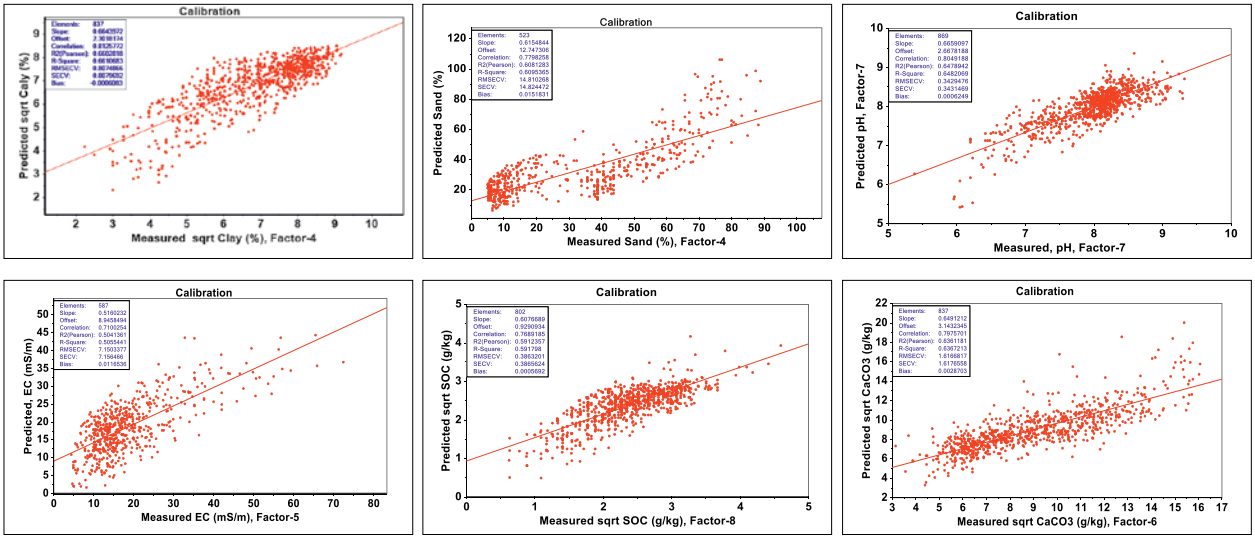
Proposed alternate land-use plan for Bundelkhand

Potential crop planning zones of Telangana: Delineation of potential crop zones can enhance understanding of specified land use objectives in terms of suitable soil and climatic features to obtain maximum productivity and profitability by conserving natural resources. This will facilitate better identification of promising crops and cropping systems, implementation or introduction of new technologies or schemes for the specified crop, replacing the uneconomical crop in the identified areas, and using natural resources to the maximum extent possible. For identification of potential areas for a particular crop, soil suitability assessment for different crops including horticultural crops was worked out in the first stage by considering available soils (1:250,000 scale) and climate information. In the second stage, the relative spread index (RSI) and relative yield index (RYI) was calculated and linked with the suitability class of a crop. A district was assigned a potentiality class based on soil suitability, RSI and RYI. Three potentiality classes namely, highly potential, moderately potential, and marginally potential are suggested. The Telangana is divided into three agroclimatic zones, viz. Northern Telangana Zone (NTZ), Central Telangana Zone (CTZ), and Southern Telangana Zone (STZ). The rice crop had a greater area (11,05,000 ha) in the highly potential class followed by maize (5,55,000 ha) in CTZ. In NTZ, rice (13,96,000 ha) was followed by wheat (9,08,000 ha) and maize (7,16,000 ha), whereas, the maximum area under the highly potential category for Italian millet (kora),



Maharashtra (PoCRA Districts) | Gujarat (Bharuch and Surat districts) | Madhya Pradesh (Datia and Morena)

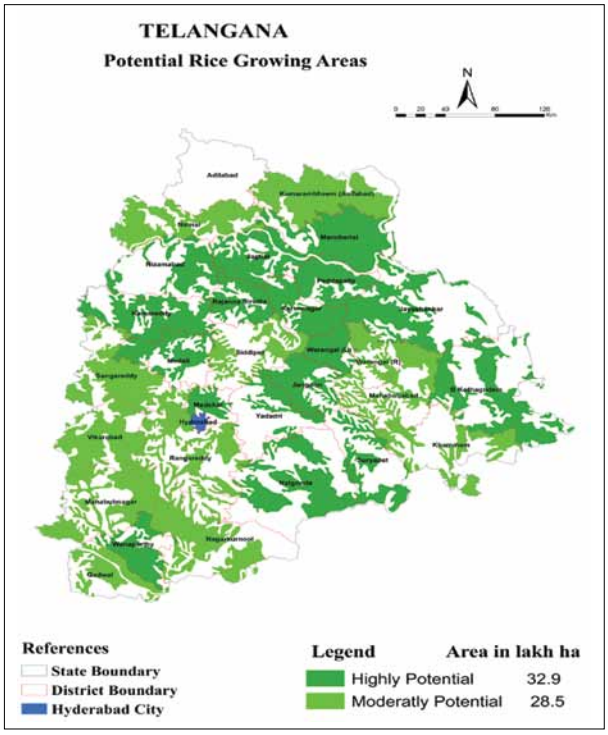
Reflectance spectra of analyzed soil samples



Predictive models developed for soil properties with spectral data

sorghum, rice, finger millet (ragi), and pearl millet (bajra) were observed in the STZ.

The evaluation of potential area for rice showed that about 61.42 lakh ha area is potential area for rice in Telangana. Highly potential areas occupied 32.91 lakh ha with moderately potential area of 28.52 lakh ha. In Central Telangana Zone (CTZ), it was observed that 11.05 and 9.31 lakh ha of area is highly and moderately potential area, respectively. Northern Telangana Zone (NTZ) had 13.96 lakh ha of highly potential area and 6.34 lakh ha of moderately potential area. Whereas, in Southern Telangana Zone (STZ), 7.89 and 12.86 lakh ha highly and moderately potential areas, respectively were noticed.

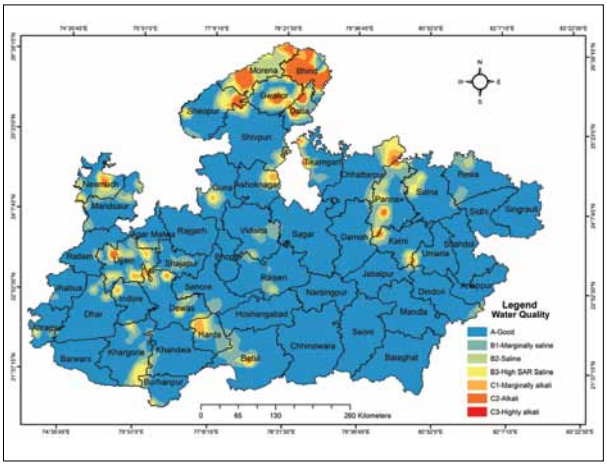


Potential area for Rice

The potential cropping systems (dominant) identified for Telangana were rice/castor/cotton/chilli (11,16,000 ha) > castor (7,82,000 ha) > cotton + chilli; cotton/chilli (5,28,000 ha) etc. which contribute around 12.2, 8.5 and 5.7%, respectively to the total cultivable area of 9,175 ha.

Ground water quality map of Madhya Pradesh: Groundwater quality map for irrigation purpose for Madhya Pradesh was prepared using data of 6,483 groundwater samples under GIS (ArcMap GIS software 9.3.1). The groundwater samples were classified into different saline and alkali categories based on pH, EC and SAR.

In whole Madhya Pradesh, 87.3% samples were of good (A) quality and 7.7 and 5.0% were saline (B) and alkali (C) categories, respectively. Out of 11 agro climatic zones of Madhya Pradesh, seven had the good quality water in more than 90% water samples. The Chhattisgarh Plains, Northern Hills Zone of Chhattisgarh, Central Narmada Valley, Satpura Plateau and Jhabua Hills agro climatic zones had good quality water in more than 95% samples. The groundwater samples of gird zone and Bundelkhand zone had poor quality water in respect



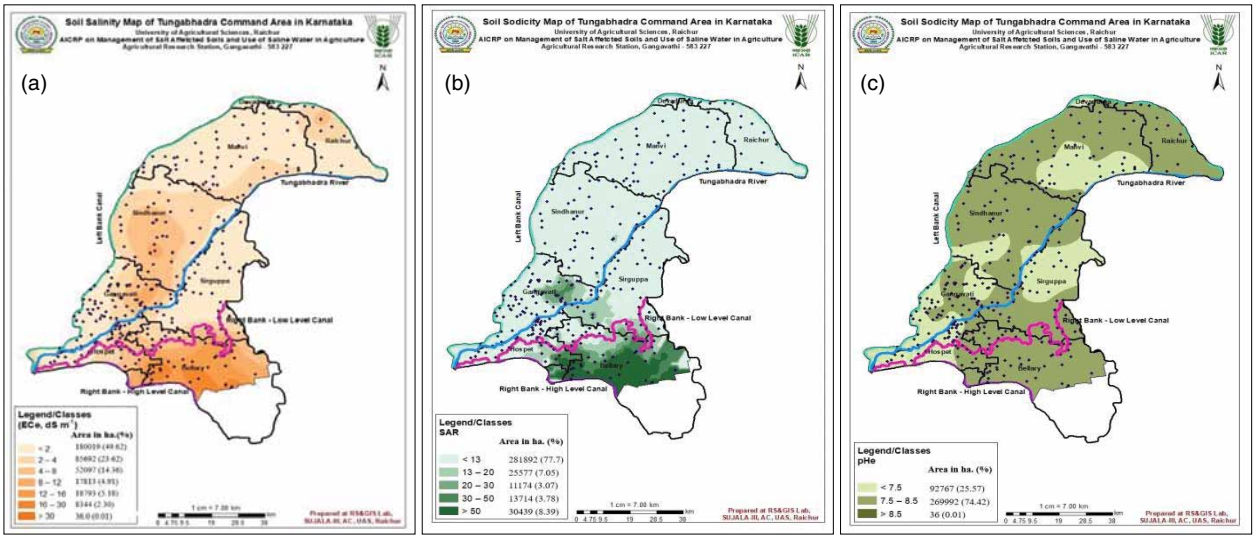
Groundwater quality map of Madhya Pradesh for irrigation

of alkali water category and represented 20.5% and 12.2% samples. On the other hand, in Malwa Plateau, 12.0 and 2.5% samples of groundwater were saline and alkali in nature, respectively. Similarly, 14.2 and 0.4% groundwater samples were found saline and alkali, respectively, in the Nimar Valley agro-climatic zone.

Characterization and mapping of salt affected soils in Karnataka: For chacterization and mapping of salt affected soils in Tungabhadra Project (TBP) command, Karnataka, a total of 312 (0-15 cm), 305 (15-30 cm), 240 (30-60 cm) and 168 (60 cm and above) soil samples were collected and analyzed for salinity appraisal from Bellary, Koppal (Gangavati), and Raichur districts in TBP command area. At surface soil (0-15 cm), the $pH_{(1:2.5)}$, pHs, EC ($_{1:2.5}$) and ECe varied from 10.76 to 5.72, 10.23 to 4.86, 3.0 to 0.10 (dS/m) and 75.0 to 0.14 (dS/m), respectively, with an average of 8.09, 7.58, 2.11, and 5.06 respectively. Among cations, average Na content (40.57 meq/l) was more than Ca+Mg (13.06 meq/l) followed by K. In case of anions, average Cl^- content was more (36.21 meq/l) than HCO_3^- (12.02 meq/l) followed SO_4^{2-}. Nearly 20% of surface samples had ECe > 4.0 dS/m reflecting that these soils are saline. With respect to area, about 23.62% (85,692 ha) and 14.36 % (52,097 ha) of the TBP command area had ECe 2.0-4.0 dS/m and 4.0-8.0 dS/m, respectively. However, nearly 50% of the area had ECe< 2.0 dS/m. In about 80% (2,81,892 ha) of the command area, the SARe was < 13 and 7% (25,577 ha) area had SARe in the range of 13-20. Soil pHs varied between 7.50 – 8.50 in about 2,69,992 ha (74%) of the command area. The percentage of samples with > 1 ratios of CO_3+HCO_3 : Cl+SO_4 and Cl+SO_4 were to the extent of nearly 12.5 and 45.5, respectively, indicating that the soils could be sodic or developing into sodic. Accordingly, nearly 23.7% of surface samples had SARe>13.

In case of subsurface samples (15-30 cm), nearly 15% of samples were considered to be saline as the ECe of these samples was >4.0 dS/m. The overall mean of the (CO_3+HCO_3)/(Cl+SO_4) was less than 1, whereas Na/(Cl+SO_4) was >1. However, about 16 and 49.5% of these samples had values more than 1 indicating that these samples could be considered as salt affected soils in particular sodic or developing into sodicity. About 23% of samples analyzed had SARe>13. Not much variation was observed with respect to the average pH, EC, pHs and ECe at 30-60 and above 60 cm depths compared to 15-30 cm.

Flue gas desulphurization gypsum-A potential amendment for reclamation of sodic soils: Flue gas desulphurization gypsum (FGDG; calcium sulphate dihydrate, $CaSO_4.H_2O$) is a by product of coal-fired power generation plants where sulphur get scrubbed from combustion of gases. FGDG has become widely available as a byproduct of forced-oxidation wet scrubbers that are used to reduce sulphur emissions (SOX) from coal-fired power plants using a spray of limestone slurry. ICAR-CSSRI and NTPC jointly initiated a collaborative work to study the efficiency and efficacy of FGDG in the reclamation of sodic soils. Results showed that the soil pHs declined by 8-11% after one year of FGDG application at 0-15 cm depth. Similarly, a significant change in pHs was also observed at 15-30 cm depth. The neutralization of soil alkalinity over the period has improved paddy crop growth and yield. The paddy grain yield increased by ~40% with FGDG compared to control. The wheat grain yield increased by ~60% with the application of FGDG in sodic soil. The FGDG was also evaluated in Haryana, Uttar Pradesh, and Punjab for its reclamation potential of sodic soils and it showed promising results.



Maps showing area (%) covered under different categories of ECe (a), SARe (b) and pHs (c) in TBP command area

Development of solar irrigation pump sizing tool: A Solar Irrigation Pump Sizing Tool (SIPS) was developed for farmers, researchers and technical persons involved in adoption and promotion of solar pumping systems across India. It comprised four modules, viz. crop`s water requirement module, discharge estimation module, head loss estimation module and the pump selection module which work on the principles laid down by the Ministry of New and Renewable Energy (MNRE). This SIPS Tool is designed to precisely estimate the irrigation demand, calculate the peak discharge and head requirements to arrive at optimal size of solar irrigation pump. The tool also considers prevalent irrigation pump sizes (using data from the Fifth Minor Irrigation Census) and different hydrological and management scenarios. In designing a solar pumping system, the tool takes into consideration the agro-ecology of the area, effective precipitation, type and seasonality of crops, number of crops grown, area potential for different crops and the pumping technology used (AC or DC; Submersible or Surface). This tool shall be helpful to support large scale installation of solar irrigation pumps.

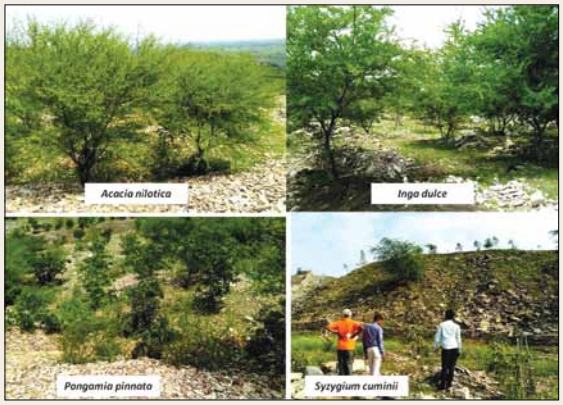
Interface of the SIPS tool: The SIPS tool involves run on a set of complex algorithms, each addressing the specific module in the design of solar pumps for a particular technical, biophysical and social setup that governs the pump set size. The tool has universal applicability in the sense that it uses nationwide datasets on climate, soils and crops, wherein users can fetch the required data for the location of interest.

Groundwater recharge planning using remote sensing and GIS: Groundwater recharge planning was done for Korba and Janjgir-Champa districts in the Mand river basin of the upper Mahanadi basin in Chhattisgarh by dividing the catchment into 13 sub-watersheds. Morphometric analysis was done for each sub-watershed. Groundwater potential zones were generated by integrating nine thematic maps namely, drainage density, slope, geology, geomorphology, soil texture, lineament, rainfall, groundwater fluctuation, and land use/land cover using remote sensing and GIS techniques. The groundwater potential zones were categorized as 'low', 'low to medium', 'medium to high', and 'high' and mapped. It was observed that a major part (42.72%) of the catchment was under the 'low to medium' potential zone, 20.27% area under the 'medium to high' category, 19.18% area under the 'high' potential zone and only 17.81% area under 'low' groundwater potential zone. Suitable sites were identified for rainwater harvesting and groundwater recharge in the 'low' and 'low to medium' groundwater potential zones in the catchment. Sites were identified for the construction of 36 percolation tanks, 39 check dams, and 21 farm ponds.

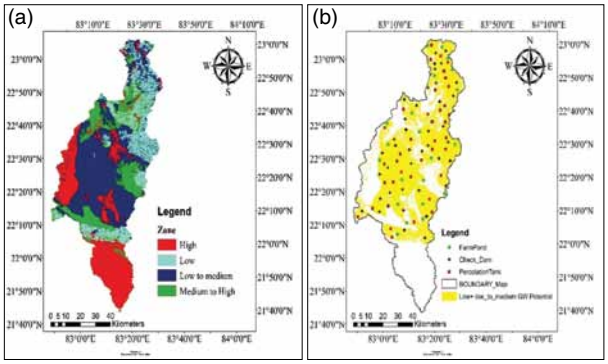
Organic fertigation system: An organic fertigation unit was developed for use of cowdung and vermicompost filtrates as a nutrient source for crops. A power-operated agitator was also fabricated for the organic fertigation unit for large-scale vegetable cultivation. The proportion of manure and water, duration of agitation, and settling time of manure solution were optimized to improve the nutrient content of supernatant and filtrate using the power-operated agitator. Vermicompost filtrate prepared by mixing vermicompost and water in a ratio of 1:5

Ecological restoration of Kota stone mine spoil

Performance of 6.5 years old four tree species at Kota stone mine spoil site was evaluated in Ramganjmandi, Kota. Amongst four trees species, viz. *Acacia nilotica* (Desi babool), *Inga dulce* (Jungle jalebi), *Pongamia pinnata* (Karanj) and *Syzygium cuminii* (Jamun) planted in the mine spoil areas of Rajasthan, with two different pitting size and four rooting media treatments, the survival rate was in the of order of *A. nilotica* (98%) >*Inga dulce* (94.2%) >*P. pinnata* (90%) >*S. cuminii* (69%).The identified tree species are highly suitable for enduring multiple benefits at Kota stone mine spoil site.



Performance of different tree species at Kota stone mine spoil areas at Ramganjmandi, Rajasthan



(a) Groundwater potential zone map of Mand river basin, (b) Sites identified for groundwater recharge

followed by agitation for 10 min and settling for 6 hr showed increased nutrient content (K, P, Ca and Mg) in the filtrate. It was recommended that organic manure filtrate along with a 50% recommended dose of fertilizer should be applied to get a higher yield of okra and improve the nutrient and microbial status of the soil.

Organic fertigation unit | Manure filtrate in tank

Okra crop under organic fertigation

CS 61 and CS 62 mustard: Two salt-tolerant mustard varieties CS 61 and CS 62 were recommended by Uttar Pradesh SVRC during 2022 for sodic soils. CS 61 and CS 62 can tolerate the sodicity up to pH ~9.3 and 9.4, respectively. These varieties yielded 2.0-2.2 Mg/ha in sodic and 2.6-2.8 Mg/ha in normal soils. The oil content is 38-40%. The variety CS 61 attains the height of ~180 cm and matures in 132 days and 1,000-grain weight is 5.3 g under sodic condition. The variety CS 62 attains the height of ~168 cm matures in 136 days and 1,000-grain weight is 5.1 g under sodic condition.

Organic farming packages: Organic farming package for 5 cropping systems namely greengram–coriander–vegetable cowpea and greengram fennel-fallow for Gujarat, sweet corn + blackgram–chickpea and soybean-fenugreek for Rajasthan and finger millet + black soybean (2:1) –wheat + toria (2:1) for Uttarakhand were developed. System equivalent yield in terms of groundnut equivalent for greengram–coriander–vegetable cowpea and greengram-fennel-fallow cropping systems was 4,717 and 2,332 kg/ha respectively. The system equivalent yield in terms of maize equivalent of sweet corn + blackgram–chickpea and soybean-fenugreek cropping systems was 7,959 and 4,955 kg/ha respectively. Finger millet + black soybean (2:1) – wheat + toria (2:1) recorded system yield (finger-millet

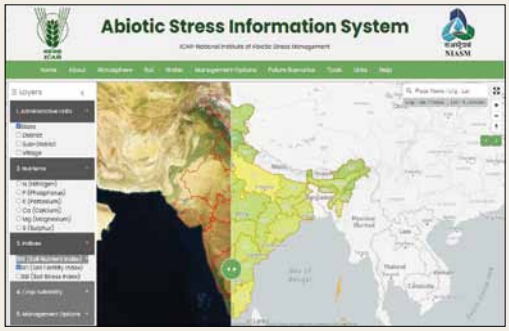
CSR 76–A promising salt-tolerant rice

The line IET 27070, CSR 2748441-195 (CSR 76) was developed from the cross CSR 27 × MI 48 and was evaluated under salt stress situation. This culture recorded good yield under salt stress situation with green foliage, erect flag leaf and long; slender grains with complete panicle exsertion. This variety was recommended by Uttar Pradesh SVRC for sodic soils. It can tolerate the sodicity up to pH~9.6. It is a medium duration with high head rice recovery variety. The grain yield is 4.0-4.5 Mg/ha in sodic soil.

Abiotic Stress Information System

The beta version of the Abiotic Stress Information System (ASIS) was developed by ICAR-NIASM and is hosted on http://117.239.43.83/asis/# (https://niasm.icar.gov.in/asis). It consists of modules on Atmospheric and Soil Stress Information (ASSI) for generating query based geo-spatial maps. The ASSI sources data using application programming interface services offered by IMD for daily weather warnings, forecast and nowcast. The soil stress information from farmer level datasets of soil health card scheme of Government of India is curated based on threshold criteria for nutrient specific values, geo-fencing and de-duplication approaches. The nutrient and soil fertility indices have been calculated up to village level using the curated datasets.

Following sub-modules listed under main menu headings have been made operational namely, Weather Warnings, Weather forecast, Weather nowcast, Weather impact on RPAS utility, GHG Emissions from Livestock (Tier-I), Soil maps, Distance and area calculators, Decadal APY maps and others are under active development. All the datasets used in development of ASIS are open-source and available in public domain. The framework of the beta version of ASIS has been developed using open-source and free tools utilizing javascript, html, python languages and GIS tools, viz. QGIS, ArcGIS, and Mapbox services. Several utilities based on dynamic weather data is being added to assist stakeholders in decision making.



Screenshot of the ASIS webpage

Salt-tolerant mustard variety

equivalent) of 2,787 kg/ha/year. Net income obtained from the different cropping systems under organic farming ranged from ₹ 0.24 lakh to 1.10 lakhs/ha. Greengram coriander vegetable cowpea recorded the higher net returns. Soil organic carbon also improved significantly due to adoption of organic farming packages. Developed package of practices shared with Department of Agriculture and Farmers Welfare and respective state agencies for promotion under various developmental schemes such as *Parambharghat Krishi Vikas Yojana* (PKVY).

***In-situ* jute-retting tank based self-reliant eco-farming system:** Keeping in view the erratic distribution of rainfall, non-availability of community retting tank, declined per capita availability of water resources, high cost of cultivation and dryness of rivers, ponds/canals, farmers face problems of proper retting of jute and mesta. Due to retting with poor quality water, quality of fibre is being affected. To overcome such problems, rainwater was conserved for *in-situ* jute retting and self-reliant eco-farming. Four such water conservation cum *in-situ* retting models were implemented by ICAR-CRIJAF for jute and allied fibres. The tank dimension of 40 ft × 30 ft × 5 ft is sufficient for retting of jute harvested from half-acre land. The total area of farming system which includes digging and bund area is about 180 m^2. Provision is made for appropriate lining of *in-situ* retting tank with LDPE agri-film of 150-300 microns or RCC to minimize the seepage and percolation loss, particularly in light textured soil. In case, large field is available, tank dimension of 50 ft × 40 ft × 5 ft can also be adopted. By integrating the construction of *in-situ* retting tank through MGNREGA scheme, large number of man days will also be created (60-70 man days/tank). In addition to retting, the harvested water can be utilized in multiple ways. On dyke based horticulture (papaya, banana, vegetables), rearing of air breathing fish (telapia, magur, singhi), apiaries, duckary, etc. can also be integrated for getting an additional income per year. The cost of transporting of harvested jute bundles to the conventional retting pond can save up to ₹4000-6000 per acre. This technology will also be helpful in reducing negative impacts from extreme weather events like drought, cyclone, flood etc. through runoff, recycling and groundwater recharge.

Demonstration of *in-situ* jute retting tank at ICAR-CRIJAF Farm

Suitability of derelict paddy fields and inland saline waters for brackishwater aquaculture: Area of derelict paddy fields identified using remote sensing was about 559 ha in Thrissur and 940 ha in Ernakulam districts of Kerala. Based on the water and soil characteristics of these abandoned paddy fields and nearby brackishwater sources, about 117 ha (21%) and 179 ha (19%) were found to be suitable for an extensive culture of shrimp or polyculture of shrimp and finfishes in Thrissur and Ernakulam districts, respectively.

Inland saline waters of Mathura district of Uttar Pradesh, on analysis showed an excess of magnesium and calcium, due to which these had higher hardness compared to that of coastal waters of similar salinity. The calcium concentration was comparatively very high affecting the Mg/Ca (0.30-2.75) and Ca/K ratios

State	Cropping system	Yield	Net income (₹/ha)	Soil organic carbon (%)
Gujarat	Greengram–coriander–vegetable cowpea (groundnut-equivalent yield)	4,717	1,10562	0.33
	Greengram-fennel-fallow (groundnut equivalent yield)	2,332	24,634	0.32
Rajasthan	Sweet-corn + blackgram–chickpea (maize-equivalent yield)	7,959	82,989	0.67
	Soybean-fenugreek (maize-equivalent yield)	4,955	66,703	0.74
Uttarakhand	Finger millet + black soybean (2:1) – wheat + toria (2:1) (finger millet-equivalent yield)	2,787	47,840	0.95

Greengram and fennel under organic production system (SK Nagar, Gujarat)

(0.45-125.53), which signifies the supplementation of Mg and K minerals. These inland saline waters are not suitable for agriculture (>5 ppt) and can be utilized for brackishwater aquaculture.

Geo-spatial mapping of deep pools in Godavari basin to monitor riverine connectivity: Rivers are dynamic ecosystems with diverse habitats that require adequate connectivity to sustain the fish genetic resources, an important component of aquatic ecosystem services. Geo-spatial mapping offer powerful tool for assessing river connectivity. The Sentinel-2 datasets (2016-21) were used in five different eco-regions, viz. Wainganga, Wardha, Pranhita, Godavari-mid and Manair in Godavari Basin in the Indian Deccan Plateau. The analysis revealed contiguous water flow in Pranhita and a section of Wainganga though the flow was feeble. The river Pranhita with deep pools and copious perennial habitats act as a repository for endemic aquatic biota in the Godavari basin as well as Indian Deccan Plateau. The obstructed flow and large-sized patches reported in river Wardha enable formation of refugia for fish species during summer months. The river continuity assessment and mapping of deep pools will be a step towards ecosystem-based conservation of fisheries resources.

Effects of aquatic pollutants on breeding biology of fishes: Study was conducted to identify deleterious effects of triclosan (TCS), an antimicrobial compound used in personal care products, and cypermethrin (CYP), a widely used synthetic pyrethroid insecticide, on fish biology. Chronic exposure of *Labeo rohita* to environmentally relevant concentrations of TCS and CYP resulted in up-regulation or down-regulation of genes associated to hypothalamic pituitary-gonadal (HPG) axis (*FSH*, *Kiss1*, *Kiss2* and *Vitellogenin*), respectively. Higher levels of reproductive hormones like 17β estradiol, 11 ketotestosterone, vitellogenin, aromatase, FSH and GnRH were observed in TCS-exposed fish while levels of these hormones decreased in CYP exposure. The biological changes would negatively affect reproductive competence affecting fish diversity and stock in open waters.

Impact of barge movement on phytoplankton diversity in rivers: The barge movement induced risk to phytoplankton diversity loss was assessed for the first time in India. An index-based risk assessment framework had been successfully developed which disentangled barge induced phytoplankton diversity loss from loss due to biological processes and predicted a substantive overall risk of phytoplankton loss of 31.44% due to barge movement for goods transportation. It was recommended that the riverine system needs sojourn time to self-regenerate plankton communities that require one day, at least. Hence, restricting barge movement for at least one day interval in the waterways can be a sensible strategy for water management and phytoplankton conservation.

Fisheries Restoration in Ganga River

Under the ongoing Governments' flagship programme 'Namami Gange', it is aimed to restore the Indian major carps (IMC) and hilsa fisheries, along with improvement of the riverine health. In this direction, the wild fish germplasms from the river were harnessed, bred in captivity and the fingerlings were ranched back in the depleted stretches of the Ganga river. So far 77 ranching programmes have been conducted with release of 5.8 million fish seeds of *Labeo rohita* (Rohu), *Labeo catla* (Catla/Bhakur), *Cirrhinus mrigala* (Mrigal/Naini), *Labeo calbasu* (Kalbasu/Keronchi), *Mystus* sp. (Tengra), *Macrobrachium rossenbergii* (Jhinga) in depleted stretches in five states during 2017-2022. The impact of the continuous effort has been noteworthy; the total fish catch has increased from 3,796.57 tonnes in 2018-19 to 4263.55 tonnes in 2019-20. Riverine health has also got positive impact as indicated by improved dissolved oxygen and other key parameters. Besides ranching, massive public awareness programmes have been organized towards conservation of broodstock, hilsa and Gangetic dolphins in the river Ganga.

Fish fingerlings being released into the Ganga river at Assai Ghat, Varanasi

Fish fingerlings being released by students into the Ganga river at Arail Ghat, Prayagraj

Nitrogen removal capacity of *Pseudomonas aeruginosa* WS L-9: Four different carbon sources namely acetate, glucose, citrate, and succinate were used for evaluating the nitrogen removal capacity of the isolate WS L-9. The results revealed that with the use of glucose and citrate as carbon source in the media, the nitrogen removal (ammonium-N) capacity of the isolate WS L-9 was more than 80%. The isolate could remove ammonium more than 80% and nitrate more than 60% after using glucose and citrate as C-sources in the media after 48 hr. Similarly, at pH 7 and 8, temperature 37°C and C:N ratio of 10, be nitrogen removal capability of this isolate was found to be more than 70%.

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10. Mechanization and Energy Management

Tractor-operated side trencher and FYM applicator for grape orchards

A tractor operated side trencher was developed at ICAR-CIAE, Bhopal to make trench up to 300 mm depth. It was tested in the vineyards at ICAR-NRCG, Pune. The effective field capacity and efficiency of the trencher are 0.2 ha/h and 71%, respectively when operated to dig a trench of 300 mm deep in 3 m wide vineyard at 2.0 km/h forward speed. The cost of operation was about ₹560/h. It saves cost of operation, labour and time by 72, 94 and 80%, respectively as compared to digging of trench manually with hand tools.

The tractor-operated FYM applicator of 1 tonne capacity was also developed for placing FYM near the plant and tested in the vineyards at ICAR-NRCG, Pune. It is operated by hydraulic system of tractor, using hydraulic motor. The side dispensing units on both sides of machinery rotates outwards through power transmission from hydraulic motor and chain-sprocket arrangement. The observed application rate was 8–10 kg/m as per recommended dose of 25 tonnes/ha. The effective-field capacity and efficiency of FYM applicator are 0.2 ha/h and 71%, respectively at 2 km/h forward speed for 3.0 m wide rows of vineyards. The cost of operation is about ₹645/h. There was saving in labour, time and cost of operation by 98, 80 and 88%, respectively as compared to manual method.

Tractor-operated drip lateral and plastic mulch layer-cum-planter

A tractor-operated drip lateral and plastic mulch layer-cum-planter has been developed to perform various field operations such as raised bed formation, drip lateral and plastic mulch laying and placing metered seed in plastic mulch in single pass of the tractor. The effective-field capacity and efficiency of machine were 0.2 ha/h and 74%, respectively at forward speed of 1.7 km/h and operational width of 1 m. The total cost and operational cost of equipment was ₹3,00,000 and ₹1,500/h, respectively. The payback period of equipment was 1.9 years (444 h) and break-even point 70 h/year. The provision is given in the equipment to match row-to-row and plant-to-plant spacing from 0.5 to 0.9 m and from 0.2 to 0.6 m, respectively by mechanical means. It helped in labour saving of 26 man-days/ha and reduce cost of operation by ₹6,600/ha as compared to existing drip lateral-cum-plastic mulch laying machine.

Tractor-operated raised-bed former-cum-planter for multiplier onions

A tractor-operated raised-bed former-cum- onion bulb planter has been developed for planting multiplier onions. The drive to the metering unit is derived from the ground wheel. A shoe-type furrow opener is fitted to the planting frame in front of onion bulb delivery tube. A funnel-shaped box was also fitted at the bottom of the seed delivery tube to prevent spillage of the onion bulb outside the furrow. This ensures an uninterrupted free-fall of the onion bulb from metering disc to furrow. The furrow opener assembly was mounted independent to the planter unit hence it can be positioned as required to ensure proper row spacing. The effective field capacity of the machine was 0.3 ha/h with field efficiency of 75%.

Self-propelled small maize harvester

A self-propelled walk-behind maize harvester for snapping the maize cobs from the maize plants and simultaneously cutting the plants has been developed. A horizontal rotary cutting blade provided at the bottom of the harvester cuts the maize stalks at the ground level. The drive for the snapping rollers and the rotary blade is provided by an 11 hp diesel engine. A collection box of 15–20 kg capacity is provided at the side of the machine to collect the cobs. Two wheels are provided at the front to facilitate the movement of the harvester in the furrows. The effective field capacity of the harvester was 0.2 ha/h and the cost of operation was ₹2,850/ha. The saving in cost of operation, time and labour were 25, 96 and 91%, respectively as compared to manual harvesting.

Unmanned rice transplanter

A remote-controlled electronic system has been developed for ride-on rice transplanter to reduce human drudgery. It is gender-friendly and easy-to -use by unskilled person to perform the rice transplanting operation in puddled paddy field. The developed system was evaluated in puddled paddy field at Paddy Breeding Station, TNAU, Coimbatore. It can be remotely operated by operator standing out of field at a distance of 200 m. The mean deviation from the travel path was observed as 0.13 ± 0.05 m as compared to 0.11 ± 0.03 m, for manually operated ride-on-type transplanter. It indicates that the developed remote-controlled system on commercial rice transplanter has good control in the puddled paddy field. The field capacity, efficiency and fuel consumption of the machine are 0.24 ha/h, 71% and 3.1 L/ha, respectively at forward speed of 1.61 km/h at slip rate of 12%.

Induction-based air-assisted electrostatic sprayer

Air-assisted electrostatic sprayer was used to spray pesticides on crops and orchards. It reduces pesticide use and pollution while increasing efficiency and bio-efficacy. The developed air-assisted nozzle has a flow rate of 120 ml/min and high voltage DC to DC charging system to charge the electrode up to 10 kV. The spray lance can operate up to a distance of 10 m. The performance of electrostatic sprayer was optimized at 1.0 km/h forward speed for 0.55 m height of application. It has 85% bio-efficacy on cotton aphids and 92% bio-efficacy on jassids for LN90 dosages of 0.15 ml/litre. The developed system can save 75% fuel, 30% pesticide and costs 20% less per ha. The cost of developed electrostatic sprayer was ₹70,000. The operating cost, breakeven point (BEP) and payback period of the sprayer were ₹2.56/ha, 78 h/year and 365 h, respectively.

Mechanization package for garlic cultivation on broad beds

A tractor-operated eight-row garlic clove dibbler was developed for precise dibbling on broad beds. The machine can dibble garlic cloves at seed-to-seed and row-to-row spacing of 100 mm and 150 mm, respectively. It was evaluated in the field for dibbling of garlic cloves in eight rows on broad beds. The depth of sowing was maintained at 40 mm during the operation. The field capacity and field efficiency of the planter were 0.22 ha/h and 73.6%, respectively at 2 km/h forward speed of operation. The missing and multiple of the machine were 3.5 and 8.5%, respectively.

A tractor-drawn garlic weeder has been developed for weeding in garlic crop sown on broad beds. The row-to-row spacing of the developed unit can be adjusted from 100 to 150 mm. The effective field capacity and weeding efficiency of the weeder are 0.13 ha/h and 63%, respectively at forward speed of 1.1 km/h and 20–25% soil moisture content.

A tractor-operated garlic harvester was developed for harvesting of garlic crop on raised beds. It has been evaluated in the garlic crop sown at 100 mm row-to-row and plant-to-plant spacing. The machine was operated at forward speed and working depth of 1.9 km/h and 60–80 mm, respectively during the operation. The effective field capacity of machine was 0.21 with efficiency of 72%. The harvesting efficiency and bulb damage during the operation were 97 and <0.5%, respectively. The development of garlic dibbler, weeder and harvester along with the adoption of existing tillage and spraying equipment practised by farmers provides a complete package of mechanization for garlic cultivation on broad beds. This mechanization package can save 34–40%

Small Scale Portable Bio-char Kiln for Biochar Production

A small-scale portable biochar kiln for biochar production from agricultural residue was developed. The input capacity of developed biochar kiln for wheat husk, maize stalk, maize cob and rice husk is 5, 4, 15 and 7 kg, respectively. The conversion efficiency was 42% for wheat husk, 41% for maize cob, 34% for maize stalk and 35% for rice husk residues. Total operating time required for carbonization of selected crop residues ranges from 84 to 104 min. The average operating temperature of the biochar kiln is 296, 254, 269 and 256°C for wheat husk, maize stalk, maize cob and rice husk, respectively. Biochar produced from wheat husk in the biochar kiln has available nitrogen (5.8 g/kg), available phosphorus (3.5 g/kg), available potassium (92.2 g/kg), phosphorus (10.7 g/kg), cation-exchange capacity (78 cmol/kg), water-holding capacity (71%) and bulk density (0.55 g/cm^3). The operational cost of biochar production by the biochar kiln is ₹78 for wheat husk, 100 for maize stalk, 54 for maize cob and ₹77/kg for rice husk. Cost for fabrication was approx ₹10,000.

cost, 75% labour and 30–35% seed as compared to the traditional practice.

Tractor-operated two-row forward-reverse rotavator for sugarcane crop

A tractor-operated two-row forward-reverse rotavator for sugarcane crop was developed. It is also useful for making deep furrows for sugarcane planting operation. In forward direction, it is used for weeding, however, in reverse direction, earthing up is performed. Field coverage is usually less in such type of forward-reverse rotavator, particularly for making deep furrows for sugarcane planting and for inter-culture operation in sugarcane crop during initial growth period of the crop. The field trials were conducted in sugarcane field at Kagal, district Kolhapur and CAAST project field at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The total area covered was 33.4 ha with 81% field efficiency. This machine is very useful for saving time, money and reducing drudgery over conventional method.

Tractor-front mounted hydraulic operated pruner

A small tractor-mounted hydraulic pruner for orchards was developed due to unavailability of suitable indigenous tractor-mounted pruner. Height of cut and the angle of inclination of the blade gangs can be adjusted with hydraulic cylinders for proper cutting and giving shape to the canopy. The pruner can prune the plant up to a height of 3.5 m. The hydraulic system is designed to rotate the blades at about 2500 rpm. The system was been evaluated at ICAR-CIAE, Bhopal, Madhya Pradesh farms of mango orchard. The pruner is able to cut the branches in the range of 3 to 65 mm at a forward speed of 1.2 km/h. Field capacity and fuel consumption of the pruner were 0.24 ha/h and 3.5 L/h, respectively. The pruning capacity of machine is 120 plants/h. The overall cost and operating cost of the pruner is ₹4,50,000 and ₹4,910/ha, respectively.

SPAD meter 2.0

ICAR-CIAE has developed a low-cost alternative, i.e. the ICAR-CIAE SPAD meter 2.0. It measures the optical density difference at two wavelengths of 655 nm and 950 nm to calculate SPAD values for crops such as rice, wheat, maize, etc. with leaves up to 1 mm thickness. The SPAD values, measured with the device, can be used to generate recommendations for top-dressing of nitrogen fertilizer dose. The electronic components of the CIAE SPAD meter 2.0 are integrated and housed in a plastic casing having an overall length of 185 mm, width of 90 mm and height of 70 mm. The measured SPAD values of the leaves are displayed on the screen of the M5 stack board. The readings of the SPAD values can be recorded in the memory card provided in the memory slot of the board. The developed SPAD meter 2.0 has comparable accuracy to that of a commercially available SPAD meter and is of low cost.

Cattle Dung-based Log-making Machine

A power-operated cattle dung-based pot-making machine was developed for proper utilization of cattle dung. Cattle dung as a base material and agriculture residues such as rice husk, rice straw, saw dust, coco peat and lime as an additive can be used for making a pot. The moisture content of pots of all the different treatments was found between 35 to 41%. The shattering index of different pots after sun-drying was 80–90%. The water-holding capacity of different pots after sun-drying was 1.06 to 1.58%. Average time required to prepare one pot is min 34 sec. The fabrication cost of the machine was estimated to be ₹40,000. The production capacity of the machine was 40–45 pots/h and the cost of operation was ₹65.20/h. The average manufacturing cost per pot was ₹4.5.

Small tractor-operated orchard sprayer

A small tractor-operated boom sprayer has been developed for orchard crops. The pump discharge rate is 36 L/min at 28 bar pressure and 950 rpm. The height of the boom is 2.7 m and consists of 12 hollow cone nozzles. Six nozzles at a distance of 450 mm are brazed on each side of the boom. The spraying system has been evaluated in guava orchards at 2.5 km/h speed of operation and droplets characteristics have been taken on water-sensitive papers. The cost of the spraying system is ₹30,000. The discharge rate of boom sprayer was 608 L/h at 0.3 MPa pressure during the operation. The application rate and turning time of the spraying system was 475 L/ha and 12 sec, respectively. The volume mean diameter (VMD) and volumetric spray deposition were 248 µm and 0.291 µL/cm², respectively.

Power tiller-operated groundnut digger

A power tiller-operated groundnut digger has been developed keeping in view relevant crop, soil and

machine parameters. The developed equipment consists of a V shape blade, lifter, frame, power transmission system, conveying mechanism and hanging curved bar for depth management. It has been evaluated in central farm of OUAT, Bhubaneswar and effective field capacity of 0.07–0.11 ha/h was observed with digging efficiency of 97.6%. The average draft at no load condition was 0.41 kN at 1.5 km/h forward speed.

Remote-controlled sensor-based site-specific chemical applicator

A remote-controlled sensor-based site-specific chemical applicator was developed. The remote control unit helps to operate the chemical applicator without entering into the field, whereas the sensors are used to spray chemicals precisely on the target (plant canopy) and avoid the space between the plants. The average forward speed of the chemical applicator was 2.2 km/h. The average discharge of the boom was 0.65 L/min. It was observed that the machine can be operated continuously for about 105 min with one charge of battery. It takes nearly 360 min to charge the discharged batteries. The effective field capacity and efficiency of the chemical applicator were 0.263 ha/h and 61.73%, respectively. The cost of operation of the chemical applicator for chilli crop was ₹ 125/h. The developed remote control unit works satisfactorily in reducing the risk of exposure to harmful chemicals during spraying by the operator.

Tractor-operated potato digger-cum-collector

A tractor-operated potato digger with collection mechanism was developed. The machine performs 3 operations, viz. digging of potato tubers (two rows), separation of potatoes from soil and collection of potatoes in the collection unit. The effective working width of the machine is 1.00 m. Hydraulic system is installed to empty the collection unit. The machine was evaluated in two different soil types at University fields (sandy loam soil), PAU, Ludhiana and V.P.O. Shah Wala (loamy soil), Kapurthala, Punjab. The best results were obtained at forward speed of 1.5 km/h and blade depth of 140 mm for both soil types. The average field capacity and output capacity was 0.12 ha/h, 2,700 kg/h for sandy loam soil and 0.11 ha/h, 2,685 kg/h for loamy soil, respectively.

Animal-drawn single-row maize planter

An animal-drawn single-row maize planter has been developed for hilly region. The implement is operated with one pair of bullocks. It has trapezoidal shaped plastic seed box having capacity of 3.0 kg. It consists of seed metering plate, shaft with adjustable opening through rack and pinion mechanism for free flow of seed in seed tube. The depth of sowing of maize seed with the planter is 50 mm. Average draft was 14.86 kg at 2.2 km/h forward speed. The average seed rate and actual field capacity were 20 kg/ha and 0.044 ha/h, respectively.

Improved animal housing structure for draught and milch animals

A solar power-assisted air -cooling system with fogger was installed inside the animal housing structure to provide comfort to animals. Solar panel of 36 W was been installed to operate DC pump with automatic time

Object-detection Model for Fruit Detection and Yield Estimation in Orchards

A study was carried out to develop an intelligent image processing methodology to count mandarin oranges on the tree and to estimate the yield. The focus was on detecting the harvest-ready and unripe fruits through Faster-RCNN and YOLOv4 object detection models, replicating human vision through convolutional neural networks. The data collection has been performed using unmanned aerial vehicle (UAV - DJI Phantom-4) from the mandarin orange orchards of Khamkheda village near Bhopal. The trees have been harvested manually, and the total yield per tree was measured to compare the performance of the developed system. The results indicated that the developed models work well in detecting both harvest-ready and unripe mandarin oranges. The mean average precision metric in detecting the mandarin oranges per tree by YOLOv4 and Faster RCNN is 80 and 76%, respectively. The manually counted and the YOLOv4 based detection resulted in a standard error (SE) of 12%.

controlled switch at discharge rate of 5.5 L/h. Twenty-six foggers were operated with solar powered DC pump at an operating pressure of 4.0 Pa to form mist of 65 micron in size. Water droplets were not allowed to fall on the ground surface. The air temperature inside the animal housing structure was 4°C less compared to the outside air temperature and relative humidity was 59%. The air-cooling system was found effective in providing comfort to the animals.

Energy inflow and outflow analysis for production of wheat crop

Energy in different forms is important for agricultural production. Increase in the level of farm mechanization has helped to enhance crop productivity and maintain timeliness in the operation. A total 220 farmer's data has been collected from 11 villages of the Vindhyan plateau based on the random selection method. Farmers under marginal (<1 ha), small (1–2 ha) and others (>2 ha) were considered to calculate energy requirement for soybean crop production. Energy consumption in seedbed preparation, sowing, fertilizer application, irrigation, harvesting and threshing were found to be 8, 16, 35, 25 and 16%, respectively. When it comes to energy sources, chemical fertilizers accounted for 33% of total energy input followed by fuel (25%), electricity (20%) and seeds (13%). The total input energy has been calculated between 13,689 to 23,544 MJ/ha. The specific energy of crop production in the selected sequence is 4.40 MJ/kg with an average energy productivity of 0.23 kg/MJ.

Reactor for the continuous production of biochar

The electric pyrolytic reactor of 12 kW capacity has been developed for continuous biochar production. The maximum biochar yield of 30% is obtained at the optimum process temperature, viz. 400°C for coconut shell, 300°C for groundnut shell and 350°C for casuarina and cotton stalk. As an energy conservation opportunity, the number of operational electric coils was reduced and biochar was produced at different temperatures with different rpm of auger to optimize the process conditions for better yield and quality of biochar. Biochar produced at 400°C with 4 rpm had better char yield (30%). The cost of production of biochar using continuous biochar reactor was ₹77/kg.

Lubricant (grease) from pine needle bio-oil

A process of grease preparation from pine needle pyrolysis oil was developed by replacing the pyrolysis oil as base oil with mineral oil and animal fat (goat) as thickener other than vegetable oil. The produced grease is good quality, eco-friendly, bio-degradable, non-toxic in nature and low cost. According to the TGA and DTG analysis of grease samples, grease of Na-based mineral oil (sample A) has the maximum thermal degradation as compared to grease of Na-base with bio-oil (sample B) and grease of Li-based with bio-oil. Cone

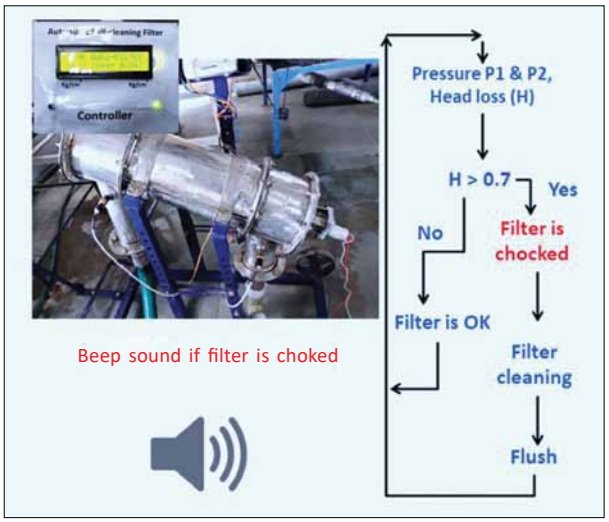
(A) Sodium-based grease (B) Lithium-based grease

Lubricant (grease) from bio-oil

Digital Flume for Open Channel Flow Measurement

A digital flume with the Internet of Things (IoT) connectivity has been developed and tested to continuously measure the flow rates in open channels. The process was developed using an ESP8266 microcontroller board, and the depth of flow was measured using an ultrasonic sensor, which allowed the discharge to be estimated using the flume's discharge equation. Utilizing the IoT, the developed digital flume measures the discharge and transmits data wirelessly for storage on cloud (ThingSpeak). It was tested in the field under varying discharge conditions. The R^2 value for the actual flow rate and flow rate measured through the developed digital flume is 0.97. It can be utilized for irrigation water measurement in the field channel.

penetration and copper corrosion values are similar for all samples, demonstrating its liquid consistency and metal-protecting nature. Slightly higher concentrations of Fe, Cu, and Pd with an extremely lower amount of Ca, Mg, Zn, and P were obtained in the grease samples. The ferro-graphical study revealed relatively few wears and contaminations in grease samples, showing that the grease behaved in good quality. This grease could be suitable for applications in areas of normal working temperatures such as roller bearings, gears, etc. The biodegradability of these pyrolysis based greases allows the wasted grease to degrade naturally and also causes no damage to the environment in the process.



Self-cleaning filter for micro-irrigation system

An automatic self-cleaning filter with simple cleaning mechanism was developed for micro-irrigation system. The controller monitors the filter during its operation through its pressure transmitters installed at inlet and outlet of the filter. It was programmed to detect the chocking stage as per BIS norm (70 kPa) and to clean it without human interventions. Controller flushes out the dirty materials from the filter after cleaning was performed. It was operated by a 1.50 kW centrifugal pump having a maximum flow rate of 20 m^3/h. The flow rate decreased from 20 m^3/h to 15^3 m/h with a pressure drop up to 70 kPa as choking increased gradually. The filtration efficiency (%) has been obtained between 22–25% and 24–28% at TSS load of 1500 and 2000 ppm, respectively.

FRP-HDPE hybrid cage deployed in Pulicat brackishwater lake

Fabrication of customized FRP-HDPE cages for open brackishwater fish farming

Coastal brackishwater areas are environmentally dynamic and highly productive. To utilize the vast stretches of brackishwater resources along the India's coasts for increased fish production as well as employment and income, ICAR-CIBA has initiated cage culture of mangrove red snapper (*Lutjanusargenti maculatus*) in Pulicat brackishwater lake. An indigenous low cost FRP-HDPE cage was fabricated and installed using single mooring. The total inner diameter of the cage is 6 m. The outer, inner collars and handrail are of HDPE, whereas the connecting stanchions are made of FRP filled with polyurethane foam (PUF). The PUF-filled FRP stanchions provided more load carrying and resistance to vertical pressure created by waves. The inner cage bag was fabricated using HDPE knotless net meshes with a total height of 3 m with 0.5 m outboard and 2.5 m carrying capacity. The total volume of cage was around 70 m^3 with a holding and production capacity of 1.4 tonnes. The snapper juveniles (450 no. /cage) with a weight range between 60 and 120 g were collected from the wild and stocked. On an average, 55 g/month growth was observed for the fishes in two months.

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Post-harvest Management and Value-addition

Post - harvest treatment machine for fruits and vegetables: Post-harvest treatments increase the shelf-life of the perishables. The machine can provide pre-cooling, washing, warm water treatment, anti-microbial treatment, anti-browning and pulsed light treatment to the freshly harvested fruits and vegetables. It also has an inspection conveyor to sort out the deformed and damaged products. This is an ergonomically designed single operator machine of size 4.4 × 1.0 × 1.6 m (length × width × height) and made of stainless (SS 304) steel. The capacity of the machine depends on the products being handled at a linear belt speed of 5 m/min. There is a provision to vary the operating speed of the machine which permits the required variations in the treatment time of commodity as per the established protocols. Water forms the medium of treatment and stored in a tank of 500 l capacity. Water jets operating at varying pressure wash the commodities. Treated and washed commodities travel on a roller conveyor where rotation/rolling and linear motion ensure adequate exposure (up to 3 s) to pulsed xenon light treatment.

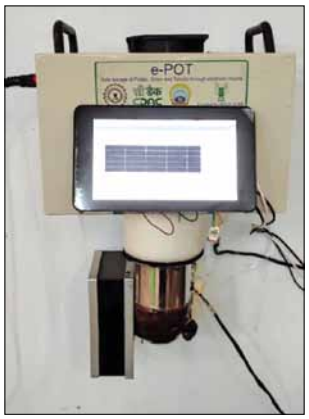
Peeling machine for medicinal tuber crops: Manual peeling of medicinal root crops such as *Safed muesli* and *Shatavari* involves drudgery and is a tedious task. A machine suitable for peeling medicinal tuber crops has been developed. It has a feeding hopper, a washing system, an abrasive peeling mechanism and a discharge spout. The peeling operation is combined with a water-spray system for the removal of peel during the operation to increase peeling efficiency. The material of construction is stainless (SS 304) steel. A re-circulatory water system reduces water consumption and effluent disposal issues. The peeling efficiency is about 92% for *Safed muesli* and 55% for *Shatavari*. The capacity of the machine is about 15–20 kg/h which is 30 times higher than manual operation. The machine is run by a 3 hp electric motor.

Pedal-operated de-bunching tool for medicinal tuber crops: Medicinal plants (*Safed muesli* and *Shatavari*) have bunches of roots with their apex ends attached. Currently, the roots are separated by manually cutting with a knife which is tedious and risky. Pedal-operated de-bunching equipment consists of a working table mounted with a spring-operated C-shaped blade, a tank for raw material and a discharge spout. The capacity of the machine is approximately 10 kg/h, with a de-bunching efficiency of 88%.

Power - operated baby corn de-husker: Baby corn (*Zea mays*) ear head with husks needs to be removed before it is further processed or stored. A power-operated baby corn de-husker has been developed consisting of a slitting section and de-husking cum desilking section. The slitting section is provided with a feed inlet pipe and two pairs of swinging arm rollers having a pair of knives. One knife is fixed between the top set of rollers and the second knife is fixed between a bottom set of rollers. A rubber fitting is provided over the remaining rollers to ensure a delicate handling/de-husking of baby corn which facilitates the flexibility to bend inwards in the feed section to accommodate different contours and geometry of baby corns. The husk is slitted on both sides longitudinally in the slitting section. After slitting, it passes to de-husking cum desilking section comprising of four rollers (300 mm in length and 75 mm in diameter) with a brush made of food-grade nylon. De-husked baby corns are collected at the main outlet, whereas husks and silky portions are collected in the husk collector set beside the machine. The slitting section and de-husking cum desilking section are operated by 0.5 hp and 1.0 hp electric motors, respectively. It has a capacity of 25 kg/h. Slitting efficiency, de-husking efficiency and desilking efficiency of the machine are 100, 92, and 100%, respectively.

Electronic nose (e-Nose) for real-time health monitoring of onion, potato and tomato under storage: An electronic sensing system (e-Nose) has been

developed in collaboration with C-DAC, Kolkata for the real-time health monitoring of the onions, potatoes and tomatoes in storage. The system consists of 8 metal oxide semiconductor sensors (MOS), equipped as an array, signal conditioning system, amplifier, Analog - to - Digital Converter, 32-bit ARM processor - based board and other auxiliary accessories. The developed system has been tested at ICAR-CIAE, Bhopal. During test operation, the user needs to select the appropriate commodity on the touchscreen display and feed in the necessary information related to the test. After that, the system automatically activates the appropriate MOS sensors assigned for a particular crop. Furthermore, the Volatile Organic Compounds (VOC) gets sniffed from the storage unit, passes through the auxiliary heating chamber and then through the sensor array. The respective sensor detects the VOC concentration and expresses it in numeric form. The values of the 8 sensors further generate a single index value through which the condition of the crop can be judged. The whole cycle of the measurement, computation and result output is completed in 7 min. The system can distinguish the differences based on VOC for all 3 commodities as the sensor readings and index value change with respect to the storage period following the specific trend.



CIAE millet popping machine: ICAR-CIAE, Bhopal millet popping machine is suitable for popping of sorghum, amaranth, finger millet, kodo millet and other small grains including rice and corn. It is an electrically operated continuous type recirculatory hot air system works on the principle of hot air fluidization process. It has a capacity of 1.4–2 kg/h with 60–70% popping recovery for sorghum and amaranth.

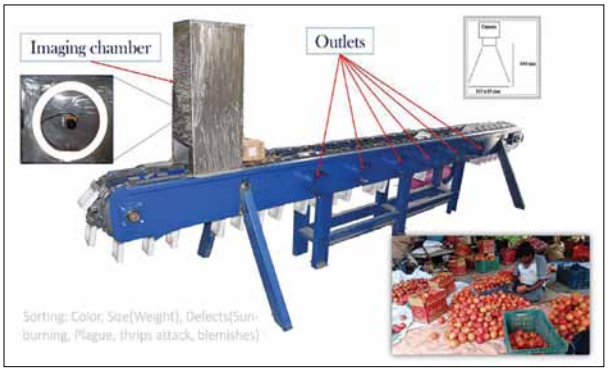
Cleaner for multiplier onion : The multiplier onion cleaner removes dead skin, chaff and impurities of de-topped and stored onion prior to marketing. The unit comprises material flow bed, air distributor, engine operated blower, feeding inlet and collecting tray. A 5-hp engine operated blower supplies air for cleaning. Air from the blower is passed through the onions falling inside the material flow bed during the process of cleaning. The feed inlet is mounted on the main frame to feed the onions on to the cleaning unit. An outlet chute has been provided at the side for dried skin and other impurities of onion to escape. Collecting tray is provided at the bottom front end of the equipment for collecting the cleaned onions. The capacity of the cleaner is 800 kg/h. The operating cost for cleaning was found to be ₹0.2/kg with 88% saving in labour cost.

Popped makhana grading machine: A simple and compact grading machine was developed by ICAR-CIPHET, Ludhiana, Punjab for grading of popped makhana of three grades (12–15 mm, 15–19 mm and >19 mm diameters) and separate flattened makhana. The grader consists of 3 concentric perforated cylinders (rectangular slots of 18 mm × 55 mm, 15 mm × 55 mm and 12 mm × 55 mm in inner, middle and outer cylinder, respectively) of 1000 mm length made from food grade metal (SS304). A conical feeding trough is placed in the inner cylinder. All the cylinders are joined together to operate at same speed. The inner cylinder is mounted on a hollow shaft, which is rotated by belt pulley arrangement. Outlets for each grade of popped makhana are placed to collect the graded makhana. The grader separates flattened and un-popped makhana near the feeding end. A 1-hp electric motor and 2 unskilled persons are required to operate the machine. Tentative cost of the machine is ₹1.5 lakh with capacity of 200 kg popped makhana per hour.

Near Infra-Red spectroscopy-based method for detection of pea flour adulteration in chickpea flour: To provide easy, fast and non-destructive method for detection of pea flour adulteration in *besan*, near infra-red spectroscopy (NIRS) model has been developed. Pea flour and *besan* samples are prepared in the laboratory and spiked samples of *besan* with pea flour (1–90%, w/w) are prepared. Spectra of pure *besan*, pure pea flour and spiked samples of *besan* with pea flour have been acquired as the logarithm of reciprocal of reflectance (log 1/R) in the Visible-NIR wavelength range of 400 to 2,500 nm. Modified partial least square regression (MPLSR) method has been developed for quantification of pea flour in *besan*. The developed model showed coefficient of determination (RSQ) of 0.99, standard error of

calibration (SEC) of 0.827 and standard error of cross validation (SECV) 1.491. The cross and test validation of statistical data revealed standard error of prediction (SEP) as 0.941 and 1.89, respectively. The statistical results showed that developed model can be used to predict adulteration of *besan* with pea flour.

Automatic sorting/grading system for tomato/ pomegranate: Automatic vision-based sorting/ grading system has been developed. It comprises a conveyor, diversion system, vision and sorting system. Cup type chain conveyor used to carry fruits (tomato and pomegranate) in singulation beneath the imaging chamber. The dimensions of conveyor, cup and pitch of chain have been kept in such a way that single fruit will be carried forward and should not drop down in between. The cup type chain conveyor has length and width of 6 m and 25 cm, respectively with cup diameter of 10–12 cm and depth of 5 cm with six grading compartments. Cups are hinged on the conveyor at one end and free at the other end for the ease of dropping the fruits/object. *Sherlock 7.3* software of *Teledyne Dalsaa* has been used to develop a programme to detect the size of fruit along with quality, i.e. presence or absence of fruit and quantify the level of defect on the surface of the fruits. After sorting, developed system grades the commodities based on their sizes. At present, machine has the capacity to sort 45–50 fruits/objects per min.



Infestation of lesser grain borer on roasted makhana seeds under storage : The internal stored grain insect (lesser grain borer), *Rhizopertha dominica* (Coleoptera: Bostrichidae) was found infesting on the roasted makhana seeds of 3 standard size grades, i.e. 7 mm, 9 mm and 11 mm. It was recorded that insects preferred to feed on 11 mm size seeds, followed by 9 mm and 7 mm, respectively. Both grub and adult stages were able to cause substantial damage. The adult laid the eggs on the seeds by entering inside the kernels through the apical natural opening. The average temperature and relative humidity for *R. dominica* development was maintained as 32.5 ± 1°C and 70 ± 5°C, respectively. It took 35–50 days for completing its life cycle, which included four stages: egg, larva, pupa and adult. Females laid about 200–500 eggs in their lifetime, singly. Incubation period lasted for 5±0.3–9±0.4 days, while larval and pupal period took 30±5 and 8±2 days, respectively. Mean longevity of adult male and female was 26 and 17 weeks, respectively. The damage potential was assessed using the artificial infestation (purposive samples) with different numbers of tested insect. The study indicated that significant loss of roasted makhana seeds during 15 days of storage with 40±1.24% losses, caused by 10 adults per 100g seeds. The total quantitative losses observed for 6 months storage period was 64±1.16% in the samples with 10 adults per 100g of roasted makhana seeds. The initial losses were very high and became slow after 20 days. Presently available method of fumigation by aluminium phosphide was practised and found feasible for the insect control.

Internal makhana feeding

Lesser grain borer (adult and grub)

Microbial precipitation process to produce protein isolates/concentrates from oilseed cakes/meals: Presently, chemical process comprising alkaline extraction and acid precipitation is followed for production of protein isolates. This addition of acid or alkali alter the functional properties of the protein, which adversely affects its quality. A novel process based on microbial precipitation process to produce protein isolates/ concentrates from oilseed cakes/meals (example soy meal, groundnut cake) has been developed. This method increased 5% yield as compared to the chemical process. The protein produced is superior in terms of solubility, wettability, water absorption capacity and degree of hydrolysis. The yield so obtained is about 35–36% of the total weight of soymeal and 25% of total weight of groundnut cake used. Biochemical analysis and lipid profiling also supported significantly superior quality.

Soy and groundnut protein supplements

Soy protein isolated through novel method

Process technologies for soy-based prebiotic, probiotic and symbiotic chocolates: Process technology for five varieties of soy beverage-based chocolates has been developed for chocolate confectionery, including prebiotic (two varieties), probiotic (two varieties) and symbiotic (one variety). These chocolates are composed of soy beverage, skim milk, cocoa butter, cocoa powder, table sugar or sucrose, inulin (conc. 0.5–2.0%) as


Prebiotic

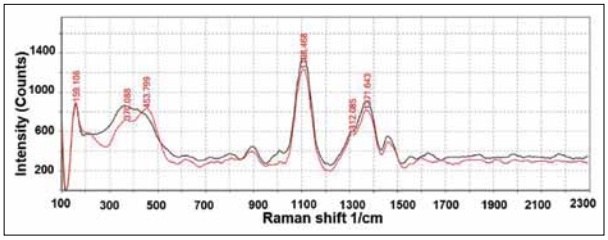

Symbiotic


Probiotic

a prebiotic and probiotic (10^6–10^8 cfu/g) culture of lactobacillus. The ingredients have been optimized using response surface methodology (RSM) on the basis of the rheological properties and taste. The overall acceptability scores of the developed chocolates have been more than 7.5 on the hedonic scale.

Marker fibres for the traceability of Naturally Coloured Cotton textiles: Globally, traceability in textile value chain has become a large concern as high profile incidents have come to light, demonstrating that many companies are unable to track where their products come from. Naturally Coloured Cotton (NCC) textiles are having niche market than conventional cotton textiles due to their sustainability advantages. There is a need to establish the authenticity of such niche products. Spectrophotometrically responsive bleached cotton fibres were produced with the combination of chemicals that can act as marker fibres. These marker fibres were blended (1% on weight basis) with NCC fibres in blow room operation during spinning process and converted into yarn and woven fabric. The presence of the markers in the final product could be detected by non-invasive spectrophotometric technique. Industrial trial on blending of marker fibres with seven bales (170 kg each) of NCC fibre has been successfully completed. Cost of production of 1 kg of the marker fibre was found to be approximately ₹600. This technique will be very useful in confirming the authenticity of fibre origin in Naturally Coloured Cotton textiles.

Process protocol for spinning of recycled cotton fibre: Re-using the existing fibres and textiles, reduces the need for newly manufactured fibres. This saves water, energy, dyes and chemicals, which results into less pollution and reduces the carbon footprint. The fibres were extracted from pre-consumer cotton knitted fabric waste. The fibre extraction process was mechanical action such as cutting, shredding of fabrics and opening fibre. The fibres obtained were short, around less than 20 mm in length, and were converted into yarn by blending this recycled cotton fibre (RF) with virgin cotton (VC) fibre in different blend proportions such as 50RF/50VC, 65RF/35VC, 80RC/20VC, 90RC/10VC and 100%VC. Since recycled cotton fibres were short, it was difficult to spin 100% recycled fibre alone. It required a minimum of 10% of long fibres for transportation or holding the short fibres when transferred between the rollers during yarn formation. The CSP of 50RF/50VC and 90RC/10VC blended yarns were 1353 and 702 respectively. The single yarn strength of the 50RF/50VC and 90RC/10VC blended yarns was 7.5089 gf/tex and 3.20524 gf/tex respectively. The strength of yarn decreased with the increase of recycled cotton proportion. Hence, the blend proportion of 50RF/50VC provided better yarn properties. The yarn having 50% recycled fibres was more suitable for home textiles applications such as bed linen, furnishing fabrics, interior decoration accessories etc.



Development of electrospun nanofiber-based zinc micronutrient sachet : Electrospun nanofiber-based micronutrient delivery matrix was developed to enhance the nutrient-use efficiency, as compared to bulk nutrient application. The needle electrospinning machine was used to produce zinc sulphate impregnated electrospun nanofibre mat. The 5 and 10 wt % zinc sulphate micronutrient was loaded with 10 wt % PVA (Polyvinyl alcohol) nanofiber. The optimised conditions for getting nutrient impregnated electrospun mat for zinc sulphate were the flow rate of 0.5 ml/h, spinneret to collector distance of 15 cm and 25 kV applied voltage. A stationary flat collector was used to collect the nanofibres; the fibres obtained were of 150 to 300 nm diameter. The nanofibre uniformity was primarily considered for optimization. The produced PVA control, 5 wt % and 10 wt % zinc sulphate impregnated electrospun mats were converted into sachets covering it with 100% cotton woven fabric to enhance biodegradability.

An *in-vitro* seed germination experiment was conducted with blackgram (Co 7) with following treatments, viz. T_1, Absolute control (No mat); T_2, Control PVA 10% mat (without nutrient); T_3, 10% PVA

Process Technology of Multi-nutrient Composite Mix for Biscuits (Patent No: 383888)

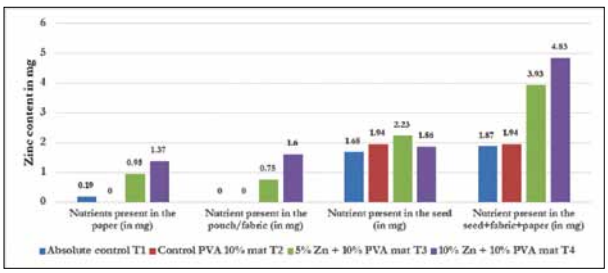
Multi-nutrient biscuits are nutritionally enriched baked products developed using corn flour, whole wheat flour, sorghum flour, malted finger millet, greengram, sprouted soybean unsalted peanuts, dairy whitener and papaya. It is rich in nutrients like energy (500 kcal), protein (14 g) valuable for combating protein deficiency and fibre (1 g) per 100g. The biscuits are rich in minerals, antioxidants, phenolics and flavonoids sourced from natural food materials. It contains no artificial flavouring or added preservatives with an adequate shelf-life (3 months). It has a high satiety value, appealing taste and is cost effective and has 21% more overall acceptability on a sensory scale over commercial biscuits. From 1 kg of dough, approximately 200 biscuits are obtained.

Process Technology for Gluten-free Eggless Cake (Patent No: 393566)

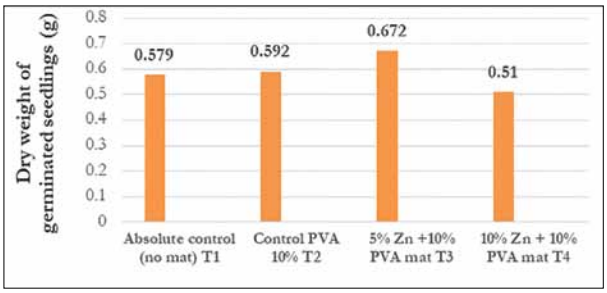
The novel cake formulation consists of malted ragi, amaranth and sprouted soybean forming gluten-free flour, banana and yoghurt as egg replacer complex and cholesterol free vegetable oil instead of saturated fat which makes it rich in protein (5 g), minerals (1.4 g), iron (4.5 mg) with good antioxidant activity for 100 g of cake. People who avoid eggs and those who have gluten allergy can celebrate their happy moment with this nutritious eggless gluten-free cake. No addition of artificial colours or preservatives and high nutritive value provide it a special place among cakes. Cost of production is ₹128/kg (at an output of 100 kg/day).

+ 5% Zn mat and T_4, 10% PVA+ 10% Zn mat with 5 replications. Fifteen seeds were directly placed on a zinc sulphate nutrient-loaded sachet which was kept on weighed filter paper. The fabric was moistened with 5 ml distilled water every day, ensuring that the sachets were wetted fully. The germination period was 8 days. The rate of germination was calculated based on the dry weight (biomass) of the sample and elemental analysis

Germination analysis of plant growth (a) 1st day, (b) 3rd Day, (c) 6th day, (d) 8th day



Germinated seed dry weight



Seed germination and nutrient absorption elemental analysis.

to understand the nutrient uptake by seed. The 5% zinc nutrient loaded (T_3) sachet trial outperformed by giving the highest mean weight of biomass of 0.672 g as compared to control biomass of 0.579 g (T_1) and positive control 0.592 g (T_2) treatments and the same was confirmed with the elemental analysis where T_3 treatment containing blackgram seeds absorbed more zinc nutrient (2.23 mg) compared to T_1 (1.68 g) and T_2 (1.94 g).

Development of 100 percent Cotton Engineered Structure fabric for face mask application: The 100% cotton double fabric structure was used to prepare multi layered (3, 4 and 5 layer) fabric face masks with high breathability and enhanced particle filtration efficiency. The produced double fabric has two different structures in a diagonal direction in a single repeat. Out of two structures, one is a highly floated structure and hence the air permeability was good and the other structure was a compact structure with high air resistance. Due to simultaneous compact and open structure in the preceding layers, the air movement was diverted and transferred through the open structure hence the air permeability was maintained. But the particles which have travelled along with air can be filtered by means of a compact fabric structure that is present in the preceding layer of the fabric. Three layered face mask had about 41% particle filtration efficiency with good breathability (Air resistance: 19.91 Pa/cm^2).

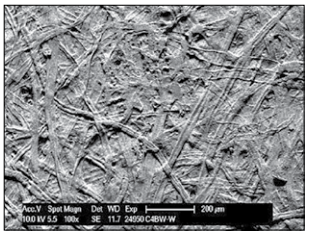
100% Cotton Engineered Structure fabric face mask

Engineered cotton fabric face mask with Electrospunnanofibre based replaceable cartridge

An electrospun nanofibre based replaceable cartridge was developed for use in above cotton fabric face masks to improve particle filtration efficiency. The electrospun nanofibre coated nonwoven fabric was sandwiched with two layers of uncoated nonwoven fabric, which can be inserted with the multi-layer face mask as a replaceable filter media. They were made with electrospun biodegradable polymer nanofibres produced in the laboratory. The produced nanofiber diameter was ranging from 100 to 300 nm. Due to finer fibre diameter and increased surface area, these play an important role in filtering the most penetrating aerosol particles. Also, they allow more air to pass within the substrate which enhances breathability. The particle filtration efficiency for the three-layer cotton face mask with nanofiber cartridge increased up to 95% equal to that of N95 mask with better breathability.

Biopolymer-based coating formulation to impart functionality to paper: A process protocol for preparation of biopolymer-based functional coating emulsions was developed to impart hydrophobicity and antimicrobial properties to paper-based fruit protection bags. The oil-in-water emulsions were prepared using natural antimicrobial agents and various concentrations of natural wax (1% w/v to 5% w/v) to achieve water repellent and antimicrobial properties. The prepared emulsions were characterized for various physicochemical properties and antimicrobial activity. Analysis of results suggested that emulsions containing combination of 2% w/v antimicrobial agents and 3% w/v natural wax were most stable with minimum particle size and maximum creaming stability during one month storage. Two types of paper (bleached and kraft) were coated with prepared emulsions. The coated kraft paper showed significant enhancement in mechanical properties (n=5) such as bursting index, 67%; tearing index, machine direction (MD), 58% and cross direction (CD), 43%; tensile index, MD, 47% and CD, 25%; and breaking length, MD, 38% and CD, 35%. Water contact angle, a measure of hydrophobicity increased from 100 to 124º. Barrier properties in terms of water vapour permeance, water absorbance ($Cobb_{60}$) and porosity were decreased by 10%, 90% and 11% respectively.

Uncoated



Coated

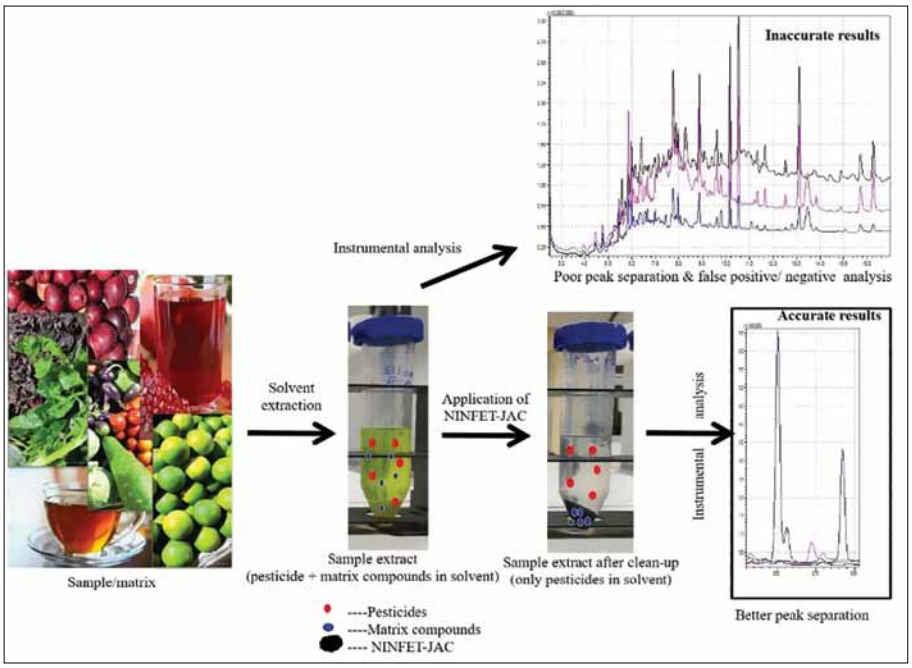
NINFET-JAC: a low-cost material for pesticide residue analysis in food: Extraction of pesticide residues from food products during analysis involves the use of graphitised carbon black (GCB), a petroleum-derived, imported and highly priced product. Application of activated carbon derived from jute stick, NINFET-JAC (Patent application no. TEMP/E-1/10590/2021-KOL), as an alternative to GCB was found effective for pesticide residue analysis in various crops like okra, spinach, pomegranate, tea etc. A production process with 35–40% yield of JAC was standardized. Developed JAC was carbonaceous (69% C as per CHNS analysis), amorphous (XRD analysis), porous (SEM analysis), thermostable (89.9% mass at 500ºC as per TGA analysis), with various functional groups (as per FTIR analysis) and large surface area (290–340 m^2/g). Unlike GCB (costing approximately 11–12 USD/g), JAC can be produced from jute stick with a tentative production cost of USD 10/kg. Hence, JAC holds immense potential as a new indigenous product under the banner of '*Make in India'* and may help the Indian food testing laboratories to perform food analysis at a lower cost, leading towards the '*Atmanirbhar Bharat.'*

Eco-friendly sustainable extraction of keratin from animal hair: India has the 3rd largest sheep population in the world having 74.26 million sheep, producing 36.93 million kg wool. Out of this about 85% is carpet grade wool, 5% apparel grade and remaining 10% is coarser grade wool (2020–21) not suitable for textile application. Wool contains about 95% keratins which have huge applications in medical and pharmaceutical industries. Coarser grade wool having

Banana Pseudostem for Paper and Functional Textile

The banana pseudostem has potential for extraction of textile fibres, sap for dyeing and finishing, and other portion for making paper-based products. Semi-solid banana plant biomass was used for making paperboard, similar to paper with higher areal density comparable with conventional handmade paper. Thickness of banana paperboard (0.8 mm) was lower than jute paperboard (1.4 mm). Tenacity and puncture load of banana paperboards (2.6 cN/tex, 199 N) were higher than the jute-fibre paperboards (1.4 cN/tex, 165 N). The banana paper board was used for making disposable moulded cutlery items, e.g. bowl (weight 3.5 g), plate (17 g) and thali (32 g). The sap of banana pseudostem was used as a bio-mordant for dyeing jute fabric and they showed better colour strength (*K/S* of 4.8) than only dyed sample (*K/S* of 1.5) with satisfactory colour fastness to rubbing and light.

Bowl and plate made from banana plant paperboard



NINFET-JAC: Low cost pesticide residue analysis in food

no textile use can be used for extraction of keratin. ICAR-NINFET, Kolkata, West Bengal has developed a microbial protocol for keratin extraction from animal hair using a keratinolytic bacterial culture AR31 which was isolated from poultry waste by serial dilution technique. The isolate resulted in about 54% dissolution of coarse wool when incubated at a suitable temperature and *p*H. Dissolution of wool takes 6–8 days, after which the liquid is centrifuged to get a clear supernatant from which keratin is precipitated with organic solvent (40–45% yield) with a cost of about ₹2,000/kg keratin.

Manufacture of high value products from nettle fibre and its blends: Fibre producing species of nettle are European nettle (*Celtis australis*) and Himalayan nettle (*Girardinia diversifolia*). The Himalayan nettle plant is abundantly available in India. It grows wild at an altitude of 1,200-2,900 m amsl in the hills of Himalayan region. ICAR-NINFET, Kolkata, West Bengal has developed 100% nettle, nettle/viscose (75:25, 50:50,25:75), and nettle/polyester (75:25, 50:50, 25:75) blended yarn and also union fabrics using cotton yarn in warp and these nettle based yarns in the weft. These blended fabrics are suitable for fashion apparel, garments, shawls, stole, scarf, saree etc.

Nettle/Silk fibre-based shawl and fashion garment

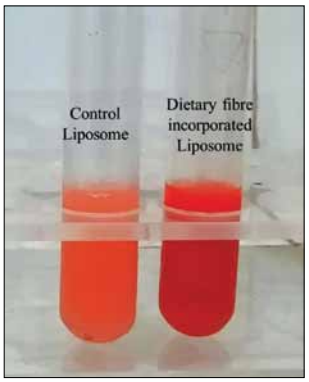
Nettle/Yak fibre-based stoles

Fine yak fibre was washed with non-ionic detergent and light alkali solution followed by acid neutralization to clean the fibre from adhering dirt, dust and greasy material. 89 tex yarn was manufactured from nettle and fine yak fiber blend in the blend proportion of 50:50 and 75:25.

Manufacturing of high value products from yak fibre: Yak plays an important role in the life and living of Indian tribes found in the difficult terrains of Himalayas. Two types of fibres, viz. the coarser and fine fibres are harvested once in a year by manual shearing and cutting process. A yak can produce 500–1,500 g of coarser and 250–750 g of finer fibres per year. After fibre surface modification 75% yak fibre was possible to blend with 25% jute fibre to produce 25/75 jute/yak fibres blended yarn. Fine yak fibre was also blended with nettle fibre [Nettle/Fine yak fibre (75:25, 50:50)] to produce yarn which was used to make shawl with silk or cotton wrap. Commercial exploitation of yak fibre can enhance the economic condition of Yak herders.

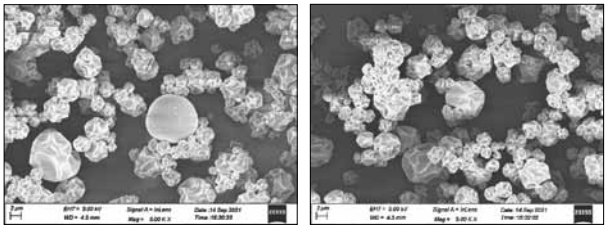
Yak fibre based fabrics and warm garments

Natural gum based dietary fibre as encapsulant for delivery of functional feed: Encapsulation of beta carotene was attempted with dietary fibre from guar gum using liposome encapsulation technique. The liposome



Liposome encapsulated beta carotene with dietary fibre

encapsulation is useful for delivery of functional nutrients due to the low absorption and increased bioavailability rates than traditional oral delivery. It requires phospholipid molecule to make a vesicle around the core material. The soya lecithin along with dietary fibre from guar gum in different combination was used to encapsulate beta carotene using liposome encapsulation technique for improving the loading stability of beta carotene. After encapsulation, the encapsulated beta carotene loaded liposomes was lyophilized for longer duration storage. The load of the beta carotene in the encapsulated liposome was estimated using UV-Vis spectrophotometer and encapsulation efficiency was found 78–80%. The liposome prepared with higher dietary fibre concentration showed higher stability as compared to the control. Characterization of liposome encapsulated beta carotene was carried out using FT-IR spectroscopy, particle size analysis and Field Emission-Scanning Electron Microscopy (FE-SEM).



FE-SEM images of dietary fibre encapsulated beta carotene through liposome encapsulation technique

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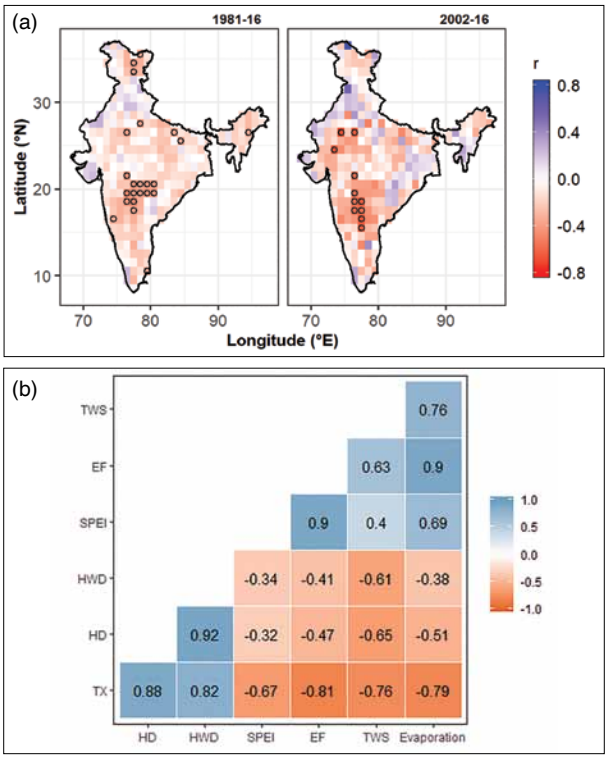
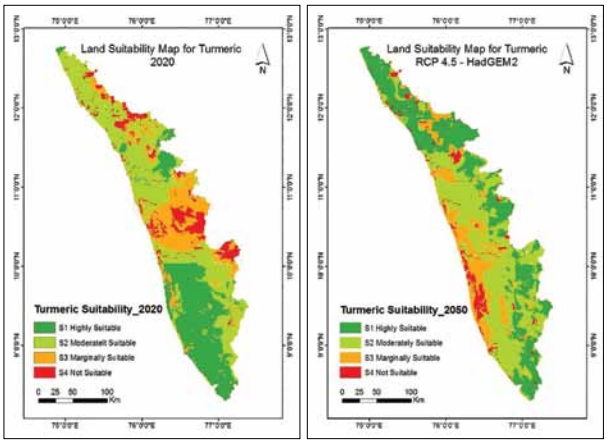
12. Climate Resilient Agriculture

Land-atmosphere interactions and extreme temperatures in India: In recent years, land-atmosphere coupling in many parts of the world was identified to have raised temperatures and aridity under global warming. Using consistent methodology and metrics from multiple data sources, it was shown that the drying land surface from the recent monsoon failures turns into a source of heat generation and drought exacerbation, because depleted soil moisture reduces evaporative cooling and increases atmospheric heating from sensible heat flux. The strength of the land-atmosphere coupling assessed through the correlation analysis supports the hypothesized mechanism as 76% of the country has shown an inverse relationship (i.e. negative correlation coefficient) between rainfall and temperatures (TX) during the post-2002 period. Furthermore, correlation of extreme temperature matrices, such as hot days (HD) and heat wave duration (HWD) with the standardized precipitation evapotranspiration index (SPEI), evaporative fraction (EF), terrestrial water storage (TWS) and evaporation were also studied. Results indicated the important role of soil moisture to facilitate the evaporation process, lack of which leads to heating of land in the backdrop of high atmospheric demand of water. Using quantile regressions, it was confirmed here in India also that an increased propensity of summer heating as surface dryness prevailed following droughts.



(a) Map of correlation coefficient (r) between rainfall and temperature (TX) during 1981-2016 and 2002-2016 delineating the strength of coupling, with circles indicating statistically significant values. (b) The post-2002 enhanced feedback in central India reflected through the anti-correlation of hot days (HD) and heat wave duration (HWD) with the standardized precipitation.

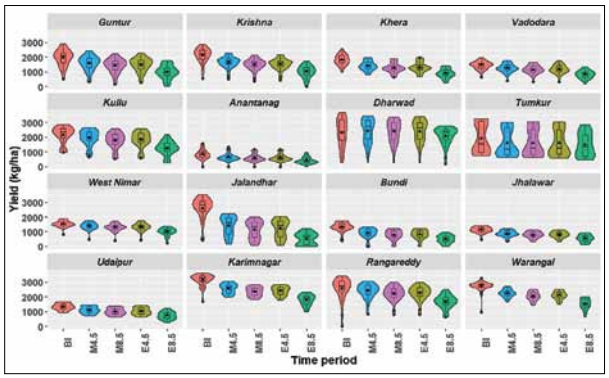
Land-suitability analysis for turmeric in Kerala under Projected Climate: Climate change is altering the land suitability for crops depending on the influence of temperature and rainfall on crop growth and productivity. Current suitability and land suitability for turmeric cultivation in Kerala in 2050 was analyzed using HadGEM2 Model based on the Representative Concentration Pathway (RCP)-4.5 climate projection scenario during 2050s. Climatic parameters considered were rainfall, maximum temperature, and minimum temperature. For each parameter, four classes (highly suitable, moderately suitable, marginally suitable and not suitable) were designated and weighted overlay analysis was conducted. Land-suitability analysis for turmeric in Kerala revealed that southern Kerala is highly suitable for turmeric cultivation while northern Kerala is moderately suitable. Since the conditions are more favourable for turmeric cultivation in southern districts, more area can be brought under cultivation in these districts to enhance turmeric production. Under RCP4.5, highly suitable area is expected to increase from the current 28% to 33% during 2050s and not suitable area is expected to decrease from the current 11% to 7% during 2050s, which is a positive sign. As highly suitable area is expected to increase by about 5% by 2050, turmeric production can be enhanced if these highly suitable areas are utilized for turmeric cultivation.



Land suitability maps of turmeric in Kerala for 2020 and 2050

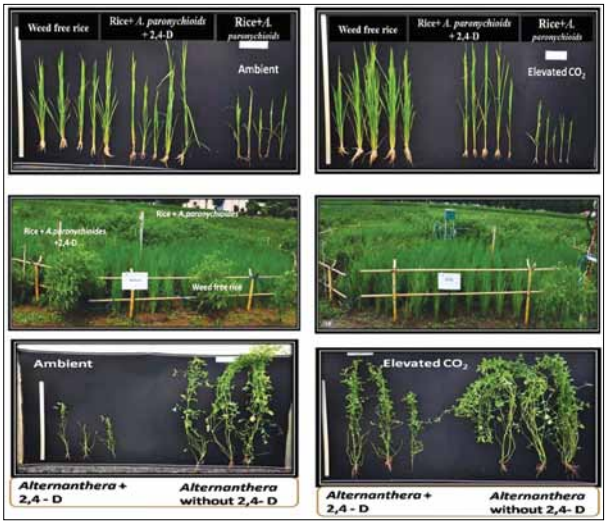
Area-specific adaptation strategies for rainfed maize under future climates of India: Spatio-temporal changes in maize yield under projected climate change were studied using multi-model ensemble climate

change projection derived from 30 general circulation models in 16 major maize growing districts of India. DSSAT model was used to simulate maize yield and evaluate adaptation strategies during mid (2040-69) and end-centuries (2070-99) under RCP 4.5 and 8.5 and identified the potential adaptation measures to reduce the negative impact. Genetic coefficients were calibrated and validated for each of the study locations. The projected climate indicated a substantial increase in mean seasonal maximum (0.9–6.0°C) and minimum temperatures (1.1–6.1°C) in the future (the range denotes the lowest and highest change during all the four future scenarios). Without adaptation strategies, climate change will reduce maize yield in the range of 16% (Tumkur) to 46% (Jalandhar) under RCP 4.5 and 21% (Tumkur) to 80% (Jalandhar) under RCP 8.5. Only at Dharwad, the yield could remain slightly higher or the same compared to the baseline period (1980–2009). It was found that a combination of individual adaptation strategies (increased fertilizer dose, supplemental irrigation, and delayed sowing time) might reduce the magnitude of yield reduction in many study locations and even expected to increase by 5, 13 and 15%, respectively during mid-century under RCP 4.5 scenario in Guntur, Tumkur and Rangareddy districts, respectively.



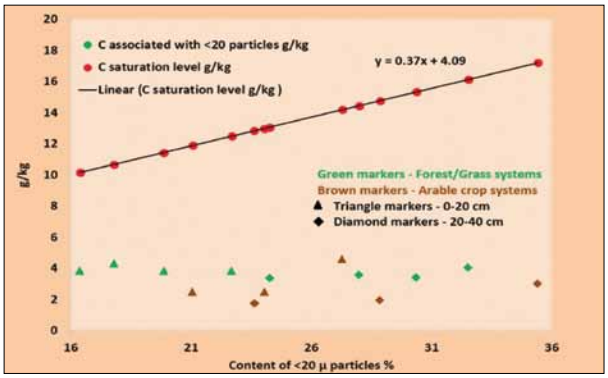
Simulated ensemble model maize yield during mid-century and end-century under RCPs 4.5 and 8.5 relative to baseline yield. *(The black triangle and black line inside each boxplot represent the mean and median of 30 years, respectively) (BI-Baseline; M 4.5-Mid-century @ RCP 4.5; M 8.5-Mid-century @ RCP 8.5; E 4.5-End-century @ RCP 4.5; E 8.5-End-century @ RCP 8.5)*

Climate change impact on weeds and herbicide efficacy: Study was initiated to assess the crop-weed interaction and herbicide efficacy under changing climate scenario using FACE facility at ICAR-DWR, Jabalpur. Growth and biomass of two major weeds, viz. *Echinochloa colona* and *Altemanthera paronychioides* in rice increased and the efficacy of herbicides, viz. bispyribac sodium against *E. colona* and 2,4-D against *A. paronychioides* was significantly reduced under elevated CO_2. Similarly, in wheat, the bioefficacy of carfentrazone-ethyl against *Chenopodium album* and *Rumex dentatus* was reduced under elevated CO_2 (550±50 ppm) and higher temperature (ambient + 2°C) in comparison to ambient levels. Under such a situation, higher dose (2×) of herbicide was required to control the weeds.



Status of current saturation against potential saturation of 0-20 and 20-40 cm soil depths under different land uses.

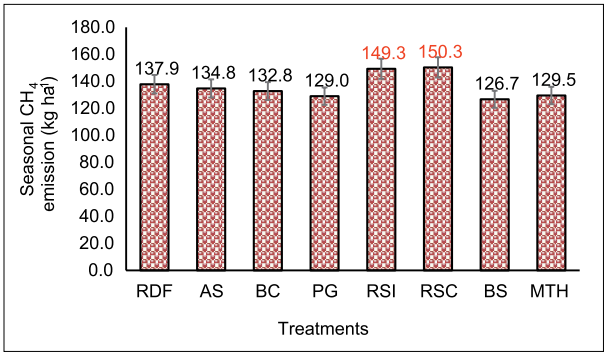
Estimating the carbon-sequestration potential of semi-arid soils: Measurement of the carbon saturation capacity and the current extent of saturation of this capacity allows an estimation of the carbon saturation deficit, which represents the soil's potential for further C sequestration. The carbon-sequestration potential of the soils was estimated using existing relationships reported in world literature. One of the assumptions in the existing relationships is that organic carbon (OC) associated with < 20 µm soil fraction to total OC in the soil ranged from 52.4% to 87.4% and was, in general, higher for cultivated soils compared to undisturbed soils with permanent vegetation. The carbon-sequestration potential of the soils up to 40 cm depth, calculated using measured values of OC in < 20 µm soil fraction ranged from 5.73 kg/m^2 in native forest land-use system to 7.72 kg/m^2 in the cropping with large C input land-use system. Carbon-sequestration potentials of the soils calculated using measured values of OC in < 20 µm soil fraction were, in general, higher than the potentials calculated using the 85% factor which underestimated the C-sequestration potential, especially for undisturbed soils under permanent vegetation. Carbon-sequestration potentials (C saturation deficit) based on measured OC in < 20 µm soil fraction were generally higher for arable systems over cultivated systems, and for soil of 20-40 cm depth over soil of 0-20 cm depth.



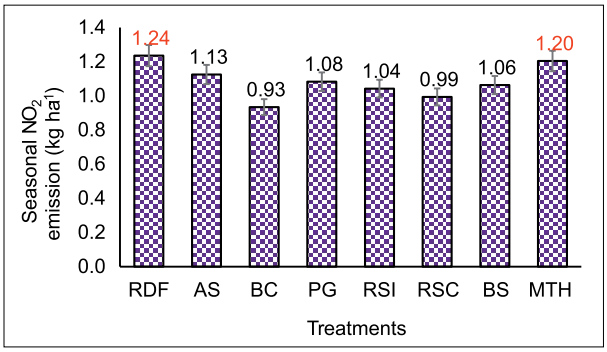
Carbon sequestration potential of soils

Mitigation of GHGs emission in rice-rice system through industrial waste: Studies on mitigating GHG emissions in rice-rice systems were taken up with eight treatments. The treatments used were: RDF: recommended dose of fertilizer; AS: Ammonium sulphate; BC: Biochar; PG: Phosphogypsum; RSI: Rice-straw incorporation; RSC: Rice-straw compost; BS: Basic slag; MTH: Methanotroph formulation. The results showed that the seasonal CH_4 emission was higher in RSC (150.3 kg/ha) followed by RSI (149.3 kg/ha) as compared to other treatments. The higher CH_4 reduction was observed in the BS (8.1%) followed by PG (6.4%) and MTH (6.1%) as compared to others. On the other hand, the seasonal N_2O emission was higher in RDF (1.24 kg/ha) as compared to other treatments. The higher N_2O reduction was observed in the BC (24.4%) and lower by MTH (2.6%) as compared to other treatments.

The average soil labile C pools (RMC, MBC and $KMNO_4$-C) were higher in rice-straw compost and rice-straw incorporation treatments at both maximum tillering and panicle initiation stages compared to other treatments. Comparing both the stages, soil labile C pools were higher at panicle initiation as compared to maximum tillering. Whereas, both dehydrogenase and FDA enzymatic activities were higher at panicle initiation than maximum tillering stage. The average dehydrogenase and FDA activities were higher in RSC followed by the MTH and RSI as compared to other treatments. The grain yield was higher under RSC (5.32 tonnes/ha) followed by RSI (5.28 tonnes/ha). The mitigation options that hamper the crop yield is not acceptable by the farmers. Therefore based on GHG emissions, Basic slag, Phosphogypsum and Biochar can be considered *on site* specific suitability.



Seasonal methane emission under eight treatments in rice-rice system



Seasonal nitrous oxide emission under eight treatments in rice-rice system

Identification of Multi-stress Tolerant Rice Variety Swarna Unnat Dhan

A high-yielding, multiple stresses tolerant rice variety Swarna Unnat Dhan (IET 27892) was developed by ICAR Research Complex for Eastern Region, Patna, Bihar for cultivation under irrigated, transplanted condition in Bihar, Odisha, West Bengal, Madhya Pradesh and Maharashtra of India. Swarna Unnat Dhan is an early duration (115-120 days), semi-dwarf, high-yielding (5.0-5.5 tonnes/ha), multiple *stress* (drought, disease and insect-pests) tolerant, lodging resistant with desirable cooking quality traits and having long and slender grain type. Quality wise, Swarna Unnat Dhan possesses 77.7% hulling, 67.4% milling, 63.2% head-rice recovery (HRR) with desirable intermediate alkali spreading value, amylose content (24.34%) with long, slender grain type. Rice variety Swarna Unnat Dhan showed moderately resistant to bacterial leaf blight, false smut, sheath-rot, leaf blast and brown spot diseases and major pests like *stem borer*, brown-plant-hopper and *gall-midge* under natural condition.

Swarna Unnat Dhan

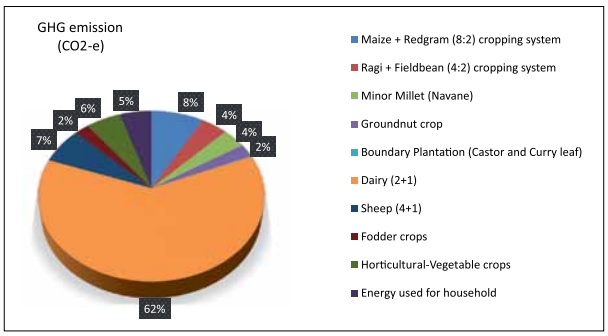
Quinoa–a new promising crop for saline areas: Quinoa (*Chenopodium quinoa*) is one of promising facultative halophytes which has been recognized recently for endurance in multiple abiotic stresses (drought, salinity, frost etc.) and for exceptional nutritional quality grain, a high potential for saline and drought prone areas. The grains are rich source of proteins (14-20%), minerals (Ca, P, Mg, Fe and Zn), vitamins (B1, B9, C and E) and oil containing large amounts of linoleate. The preliminary results of evaluation of quinoa germplasm at ICAR-CSSRI, Karnal showed that some germplasm produced satisfactory grain yield of about 6.2 to 7.0 g/plant under high SAR irrigation water salinity of 24 dS/m. Under field conditions, grain yield of more than 3.0 Mg/ha was obtained in the saline soil of 6-8 dS/m EC_2. Efforts are being made to explore the more genetic variability for salt-affected agro-ecosystem of the country with standardization of management practices.

Integrated farming system model for dryland of Karnataka: Ecofriendly integrated farming system model was developed suitable for dryland areas of Karnataka for improving the income of the farmers, better soil health, reducing the consumption of mineral fertilizers through recycling and meeting the human and livestock nutrition. One-acre dryland-based IFS

comprising cropping systems [(ragi + field bean (4:2), maize + redgram (8:2), minor millet (Foxtail millet), and groundnut, orchard (fruits + vegetables) + fodder + boundary plantations (Castor and curry leaf) + livestock (cow-2 and sheep-5)] developed at Kathelgere, Karnataka resulted in improvement in net income by 65.7% (₹52,700/acre) with B:C ratio of 2.68 over maize as sole crop (₹31,800 and 2.21 B:C ratio) practised in dryland systems. About 11,342 kg of residues were recycled back in the system worth ₹9,102. Quantity of mineral fertilizers saved due to recycling was about

Ragi + field bean (4:2) Foxtail millet

127.1 kg urea, 270.7 kg of SSP and 68.9 kg of muriate of potash. IFS model recorded Sustainable Yield and Value index of 0.68 and 0.71, respectively. Greenhouse emission estimation from the model indicates although livestock recorded higher GHG emission (2,086.2 CO_2-e in kg) and lowest GHG emission was recorded from border plants (castor and curry leaf) (4.5 CO_2-e in kg) and the total GHG source in the system (3,371.6 CO_2-e in kg) and sink was (4,487.3 CO_2-e.kg), overall negative trend in GHG (-1115.7 CO_2-e.kg) was noticed, hence, the system proves to be ecofriendly model.



GHG emissions from one acre IFS model

Developing, validating and disseminating innovative cutting edge technologies for rice-based production system: Android based digital real time N application app 'riceNxpert' was evaluated vis-à-vis SPAD meter and Customized Leaf Colour Chart (CLCC) showed the potential of improving N-recovery efficiency by 8-14%. Methodology for loading nano-clay-polymer composites (NCPC) with low molecular weight organic acids and P was standardized. The NCPC loaded with diammonium phosphate (DAP) and citric acid (CA) acted as a smart delivery system, which slowed down the P release compared to raw DAP. A simplified and farmer friendly tensiometer was developed and irrigation scheduling based on this tensiometer was observed to mitigate methane emission by 51% and global warming potential by 21%. The NRRI – ARM (Aerobic Rice Moisture) sensor for real time soil moisture monitoring in rice fields was developed, which has potential to save irrigation water input by nearly 41%. Mass production of *Azotobacter chroococcum* Avi2, phosphate solubilizing bacteria (*Ensifera dhaerens* PSB 14) and exopolysaccharides producing bacteria (*Bacillus* spp. EPS-1) was standardized using Jensen's (JM), Pikovaskaya's (PM) and M1 (MM) media. Application of *Trichoderma* NRRI formulation @ 10 g/kg of seeds as seed treatment enhanced yield of CR Dhan 314 by 13.1%. Agroecological intensification of rice-maize cropping system by introducing direct seeded rice of CR Dhan 314 followed by maize+ground nut resulted in higher system productivity as compared to rice - maize + cowpea cropping system and sole rice-maize cropping system. Study on effect of crop geometry and spacing on

Improvement of Yield and Climate Resilience of Rice through Genome Editing

Genome-editing technology (CRISPR-Cas9) was used to create loss of function mutants of the *Drought and salt tolerance* (*dst*) gene, a Zinc finger transcription factor, in rice cultivar MTU 1010. Three homozygous mutants were developed with reproductive stage tolerance to salinity stress. These lines were further evaluated for yield under drought stress and non-stress conditions. The *DST* gene mutants showed >25% increase in grain yield under normal conditions due to increase in reproductive tillers per plant and grain number per panicle. Under drought stress (-75 KPa), genome edited mutants showed significantly higher grain yield as compared with MTU 1010.

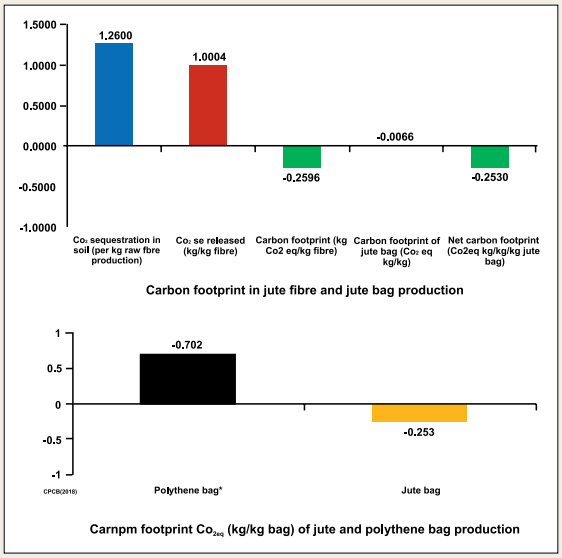
Genome editing of *DST* gene enhanced grains per panicle and grain yield in rice.

Genome editing of *DST* gene enhanced tolerance to drought stress (-75KPa) of rice.

Photographs show drought stress effect on visible appearance of plants (*left panel*) and grain yield of plants (*right panel*). WT, MTU 1010; D2bp, genome edited line of MTU 1010

Jute: An Environment-friendly Material and Greenest Alternative to Plastic Bags

Increasing demand for jute made shopping carry bag materials has given rise to various issues relating to their disposal as well as to the overall environmental footprint and sustainability of the packaging materials. Life Cycle Assessment (LCA) study was conducted of all inputs and outputs, aggregated in the form of resources used and environmental emissions, extending from the production of raw materials to the final disposal of the product. The system boundary chosen in this LCA study was cradle-to-grave, i.e. from jute cultivation to the disposal of jute bags. The global warming potential (GWP) for the production of one kg of jute bag is approximately -0.253 kg CO_{2eq}. The negative sign indicates a net sequestration of the CO_2 in the soil by the cultivation of jute crops in 120-125 days. Approximately 1.26 kg CO_{2eq} is assimilated at the agricultural stage, with the release of 1.00 kg/CO_{2eq} for the production of 1 kg of raw fibre at the farm stage. A jute bag can be reused more than 30 times as its primary use for shopping and packaging. The jute bag degrades within 150 - 160 days if mixed with soil under normal environmental conditions. The overall climate change impact of jute bags from agriculture farm to the usage and disposal phase is net carbon-sequestration, i.e. sequestering more CO_2, than is emitted in the entire life cycle stages. The excess sequestered carbon is left in the form of fixed carbon in organic matter, and this increases the soil fertility. Thus, the jute bag is an environment-friendly material from a climate change perspective and a good example for circular and green economy.



Carbon footprint of jute and plastic product

submergence tolerance of tolerant and susceptible cultivars indicated that hexagonal arrangement and wider spacing (20×15 cm) enabled better tolerance against the submergence stress. Land use and land cover change analysis for six coastal districts in Odisha (Balasore, Bhadrak, Kendrapada, Jagatsinghpur, Puri and Ganjam) at 5-year interval since 1990 to 2018 indicated a steady decline in agricultural area dominated by rice-based cropping systems.

Methane emission in animals: Study was carried in sheep to ascertain the impact of divi-divi (*Caesalpinia coriaria*) pod supplementation on enteric methane emission, rumen microbial diversity including methanogens, and rumen fermentation characteristics. The control group was fed a basal diet, and in the test groups, divi-divi pods were included at three level in the basal diet (3.5, 7 and 10% of concentrate). The results indicated a significant reduction in daily enteric methane emission with the supplementation of divi-divi pods at the 3.5 and 7.0% levels, and the supplementation adversely affected the abundance of rumen methanogen *Methanomicrobium mobile*.

Divi-divi pods evaluated for anti-methanogenic potential in sheep

The enteric methane emission and archaeal community composition in cattle and buffaloes that fed same diet comprising 70% finger millet straw and 30% concentrate was compared. Enteric methane emission was quantified using SF_6 tracer technique following the 30-day feeding period. The results indicated significantly ($P<0.01$) greater enteric methane emission in cattle (175 g/day) than buffalo (130 g/day). However, the methane yield per unit dry-matter intake was similar between these species.

Estimation of enteric methane emission in cattle and buffalo using SF_6 tracer technique

Characterization of rumen bacteria for methane reduction: Eleven nitrate reducing bacterial isolates were morphologically, biochemically and phylogenetically characterized for their ability to reduce methane.

Himalayan Forest Tree Leaves for Reducing Ruminal Methanogenesis

Three multipurpose Himalayan forest tree leaves, viz. Nevaro (*Ficus roxburghii)*, Lute khanew (*Ficus clavata*) and Thotne (*Aconogonium molle*) were collected from Sikkim. Lute khanew tree leaves were used as herbal feed additives to manipulate rumen fermentation for reducing ruminal methanogenesis for efficient utilization of dietary energy to improve productivity of ruminant animals. Ruminal gas and methane production was lowered (P<0.05) when 25, 50 and 100 mg of control substrate (contained 60% paddy straw and 40% concentrate mixture) was replaced by Nevaro or Lute khanew or Thotne tree leaves. However, lowest gas and methane production were observed due to inclusion of Lute khanew (*Ficus clavata*) tree leaves as feed additive in the control substrate. The anti-methanogenic activity of Lute khanew tree leaves was higher than Nevaro and Thotne tree leaves. There was a reduction of 24.7, 45.21 and 64.5% in methane production per g digested dry-matter when 25, 50 and 100 mg control substrate was replaced by Lute khanew tree leaves, respectively. The Lute khanew tree leaves may be used as herbal feed additives to manipulate rumen fermentation for reducing ruminal methanogenesis for efficient utilization of dietary energy to improve productivity of ruminant animals.

Lute khanew (*Ficus clavata*)

The highest nitrate and nitrite reduction was observed with RM 220 characterized as *Selenomonas ruminantium* OK605906. A reduction of 16% per unit of DDMI in methane production with 2% nitrate supplementation was found *in vitro*; however, supplementation of nitrate reducing bacterial cultures either daily or alternate week have not exerted any extra effects on methane reduction and performance of buffaloes.

Water footprint analysis of cattle and buffalo: Water footprint was assessed for lactating Vrindavani, Tharparkar and Sahiwal cows and Murrah buffaloes. In lactating animals, consumptive water usages (CWUs) for washing of covered area of sheds differed significantly between the species and breeds of the animals. The total consumptive water use (total of all the CWUs from direct and indirect water consumption) of lactating Vrindavani cows was significantly higher (6,558.67±81.54 l/animal/d) than Tharparkar cows (4,445.58±67.23 l/animal/d), Sahiwal cows (4,317.85±73.39 l/animal/d) and Murrah buffaloes (5,512.06±67.48 l/animal/d). The Murrah buffaloes (38,46,955 l/animal) utilized significantly higher quantity of water from birth to the day of first calving followed by Tharparkar (28,62,083 l/animal), Vrindavani (28,01,903 l/animal), and Sahiwal (25,52,742 l/animal) cows. The water footprint for milk production in Vrindavani, Tharparkar, Sahiwal cows and Murrah buffaloes were 657.79±38.36, 867.68±83.34, 881.42±102.29 and 832.50±63.57 l/kg milk, respectively.

Tomato Hybrid Kashi Adbhut (VRNTH-18283) for high temperature: Suitable for high day temperature of 38±2°C and night temperature of 32±2° C. Semi-indeterminate plants, fruit weight 60-30 g with yield potential of 520 q/ha, having TSS 3.7^0 Brix and acidity 0.25%. Crop duration February to June under north Indian plains. Availability of fruits up to 2nd week of June. Identified by Institute Technology Identification Committee. Proposal for release and notification submitted to U.P. State Government in April 2022.

Tomato Hybrid Kashi Tapas (VRNTH-19095) for high temperature: Suitable for very high day temperature of 38±2°C and night temperature of 32± 2°C. Semi-indeterminate plants. TSS 5.4^0 Brix & acidity 0.38%. Yield potential is 448 q/ha. Fruit weight is 45-40 g. Crop duration February to June under north Indian plains. Availability of fruits up to 1st week of June. Identified by Institute Technology Identification Committee. Proposal for release and notification submitted to U.P. State Government in April 2022.

Radish Hybrid Kashi Rituraj (CMS based F_1 hybrid) for year round cultivation including high temperature: First CMS-based F^1 hybrid of radish from public sector in India. It is lush green sinuate leaved, long rooted, medium duration, high temperature tolerant, wide adopting, high yielding with an improved root uniformity. Root colour is white and shape is tapered (iciclical). Less pungent at low temperatures of winter season. Capable of giving yield at very high day temperatures of 38-43°C. Yield potential winter 600-650 q/ha, Spring and Autumn 350-400 q/ha and Summer 320-350 q/ha. Suitable for cultivation all-round the year except during excessive rain under north Indian plains. Identified by Institute Technology Identification Committee. Proposal for release and notification submitted to U.P. State Government in April 2022.

Spinach beet/Palak Variety Kashi Baramasi (VRPLK-2) for year round cultivation including high temperature: Leaves are attractive, smooth, succulent, lush-green with entire margin. Gives yield even under high temperatures of 39-42^{0}C from April to June under north Indian plains. Delayed bolting hence higher biomass production. Dry-matter is about 15-16% and good source of vitamin C i.e. 65-75 mg/100g FW. Yield potential 180-235 q/ha from March-July, 500-

900 q/ha from August-November and 120-70q/ha from December-February. Suitable for cultivation all-round the year. Identified by Institute Technology Identification Committee. Proposal for release and notification submitted to U.P. State Government in April 2022.

Simulation studies using InfoCrop Potato Model: For developing adaptation strategies against climate change for Madhya Pradesh, the model showed that under RCP 4.5 yield of Kufri Jyoti could be improved by 5.9% in 2030, 5.5% in 2050 and 4.3% 2080 future climate scenario over the farmer's practice, when irrigation (50 mm each) was applied at 5 days interval along with N application @180 kg/ha.

MaxEnt' model was used to evaluate the bioclimatic variables determining the regions suitable for coconut cultivation and to predict the regions with potentially suitable climate under future climate conditions.

Analysis of differentially expressed transcripts (DETs) revealed that, 486 cocoa water-deficit stress responsive transcripts are specific to the genotype VTL C15, whereas 505 water-deficit stress responsive transcripts are found in cocoa genotype VTL C22.

❑

13. Human Resource Development

India, with 74 Agricultural Universities comprising State Agricultural Universities (SAUs), Deemed Universities (DUs) and Central Agricultural Universities (CAUs) is one of the largest agricultural research, education and extension systems globally. The uniformity, assessment and maintenance of standards and quality of higher agricultural education through institutional mechanism has been put in place in Indian Council of Agricultural Research (ICAR) for human resource development and quality reforms. The Council has been providing support for strengthening, development and quality assurance of higher agricultural education and plays a leadership role towards building and nurturing future ready agri-graduates and skilled human resources, to meet the challenges of maintaining productivity, production and nutritive value in a sustainable way. The Division through the implementation of scheme-Strengthening and Development of Higher Agricultural Education in India, assists the AUs to plan, undertake, aid, promote and coordinate agricultural education in the country. The Council through its Agricultural Education Division helps maintain quality assurance across agricultural universities (AUs), through strengthening, modernization, periodic upgradation of course curricula and through rigorous accreditation process. The scheme helps in promoting holistic higher agricultural education by blending knowledge and skill through Experiential Learning Models, thereby promoting entrepreneurial capabilities of students.

The effective functioning of National Agricultural Research and Education System (NARES) is because of close association with education and extension leading to contribution towards the rapid growth of agriculture in the country. The education and skills of agricultural people are significant factors in enhancing every aspect of agricultural performance.

Quality assurance

Accreditation of Agricultural Universities: A total of 34 new applications for accreditation of degree programmes, colleges and Agricultural Universities were received in the year 2022. Twenty-five Agricultural Universities, including backlog of previous year, were granted accreditation, whereas two agricultural universities were not approved for accreditation. Further, based on request, four colleges/programmes belonging to state Agricultural Universities/ General Universities were granted accreditation, separately, in addition to the Agricultural Universities. Among the private universities/colleges, 23 universities were granted accreditation, whereas, about 10 universities could not qualify. Presently, 53 applications are under process at various levels such as University, Regional centres, Peer review teams and Accreditation secretariat. About ₹55 lakh revenue was generated through accreditation fee during the period.

Ranking of Agricultural Universities: In line with the National Initiative on Ranking of Indian Institutions, ranking of Agricultural Universities has been initiated by ICAR with a larger objective to drive the universities towards improving quality standards and enhance their visibility to enable them for participation in global rankings. The ranking status allows the students to make informed choices for university placement. Further, the ranking process is expected to help the universities to self-assess themselves on the quality and enhance their abilities. It also tends to improve healthy competition among universities.

As the mandate of Education Division is "to enhance the quality and relevance of higher agricultural education in the country", the ranking of agriculture education has been assigned to the Education Division. Accordingly, the ranking process was initiated in 2017 as per the proforma developed by NAAS. Since then, the proforma has been modified based on the experience and also the inputs received from various stakeholders.

Restructuring of PG and PhD programmes through BSMA: A National Core Group has been constituted for development of Academic Regulations for Masters and PhD programmes, defining names and curricula for uniformity and revision of syllabi for courses of Masters' and PhD degree disciplines. On the recommendations of the members of National Core Group, 19 Broad Subject Matter Area (BSMA) Committees have been constituted for revising the syllabus. The syllabi developed by the 19 BSMA committees for 79 disciplines were reviewed by the National Core Group on 12 January, 2021 and recommended the reports, except on the number of disciplines in Fisheries Science, inclusion of Organic Farming and Wildlife Sciences as new disciplines, along with common academic regulations. These proceedings were released on 3rd December, 2021 and are available on education portal of ICAR.

Student READY: Under Rural Awareness Work Experience (RAWE) component of student 'READY' the students are exposed to the rural settings and work with the farmers, helping them solve their problems and learning indigenous technologies from the farmers. They get first-hand experience regarding the challenges faced by those involved in agriculture and allied areas. Apart from imparting knowledge to farmers about latest technologies, crop protection methods, etc. the students themselves are exposed to managing commercial farms during visits to progressive farmers. The students are also exposed to various agri-industries in the region for internship. The course is offered, therefore, to ensure hands-on experience and practical training, depending on the requirements of respective discipline. During the last one year 19,557 students were trained under RAWE through Council's support. An online portal for data recording under the Student READY programme has been developed.

Students working in the field and interacting with farmers under RAWE component of the Student READY Programme

Experiential learning modules: During the year, six new experiential learning modules were provided to six Agricultural Universities, viz. BASU Patna; UAS, Bengaluru; DBSKKV, Dapoli; CAU, Imphal; MPUAT, Udaipur and RLBCAU, Jhansi and a total number of 490 modules across SAUs. The new modules were selected under various themes, viz. Breeding and culture of freshwater ornamental fishes, Mass production of bio-agents, Forestry, Natural farming, Spices processing, and Commercial horticulture. An online portal for monitoring the Experiential Learning Programme was made operative and several meetings of the stakeholders were conducted for data recording on the portal.

Preparation of value added products under Experiential component of Student READY Programme

Exhibition of apparels by Apparel Manufacturing module students under Experiential component of Student READY Programme

Human Resource Development

Teaching, Research and Capacity Building

Niche area of excellence: The NAE programmes are being supported in the important focussed areas, viz. development of blast resistant varieties in rice, assessment of heavy metals in crop plants, development of nano-material for tissue regeneration in animals, etc. for strengthening research in specific strategic areas in agricultural education, research, and capacity building.

Significant achievements:

- Under the ongoing program on tissue regeneration in animals at IVRI, *in vitro* trans-differentiation of canine bone marrow derived mesenchymal stem cells into neurons was achieved.
- Stem cells laden with bone nano-scaffold (PCL+HA+MWCNT) significantly accelerated bone healing in critical bone defect in animal model than conventional treatment.
- Stem cells laden with neural nano-scaffold (PCL+ Collagen +MWCNT+ Br) accelerated neuro-regeneration in crushed nerve injury in animal model.
- Stem cell laden nano-scaffold is also being standardized for regeneration of cartilage *in vitro*.
- Development of blast resistance high yielding short

Pre-defect D-0 D-30 D-60 D-90

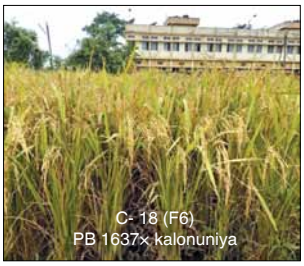
Radiological evaluation of Stem cell laden nano-scaffold groups show extensive new bone formation in the bone defect site

Stem Cell therapy for nerve regeneration study *in vivo* model. (A) Sciatic nerve injury in rat's *in vivo* model and use of nano-scaffold laden MSC at crushed nerve injury site. (B)After nano-scaffolds laden stem cell (PCL + collagen + MWCNT + Br polymer) therapy,nerve sensation regained in the affected limb.

grain aromatic rice varieties is being supported in UBKV, Coochbehar. In this program, F_7 and F_8 generations of Kalonunia×Pusa Basmati 1637 were screened for the presence of Pi9 genes and approximately 200 positive event were selected for the next generation.

- 50 isolates were characterized morphologically and molecularly from north Bengal regions and confirmed as *Magnaporthe oryzae* by ITS sequencing with known primers.
- Plants were screened for Pi9 gene through molecular screening with the help of molecular marker and plants with Pi9 gene tagged in field.

Line number G-5-7 (RIL developed from IET 21959 (Pi-9) × Kalonunia (Popular non-basmati aromatic genotypes from North Bengal); Pi9 positive, slender grain, aromatic.



Line number C-18 (RIL developed from IET 21959 (Pi-9) × Kalonunia (Popular non-basmati aromatic genotypes from North Bengal); Medium slender grain, aromatic.

The NAE centres organized 2 training programmes /awareness workshops/camps, leading to capacity building of 248 faculty and 20 students undergoing internships. 4 PG students completed degree programme and 18 students are continuing research work and pursuing degree, utilizing the facilities developed under NAE programmes. These centres published 6 papers in peer reviewed journals, including papers in journals assigned NAAS rating of 7 and above. Three technologies/ methodologies have been developed and are under process for commercialization.

Summer/winter schools and short courses: During the year, 72 summer winter schools/short courses comprising 41 summer/winter schools of 21 days, and 31 short courses for 10 days were organized at various ICAR institutes and SAUs. The skills, knowledge and capacity building of 1903 (1340 M/ 563 F) faculty were enhanced. All the training programs sponsored by Agricultural Education Division were monitored through workflow based online management system.

Attracting of talent

All-India entrance examination for admission to UG: Counseling for 26th AIEEA-2021 (UG) was completed online and out of 2879 seats available for admission; a total of 2098 seats were filled from ICAR quota in different universities under ICAR AU system. The 27th Undergraduate Examination (AIEEA 2022) for admission to 15% seats (100% seats at ICAR-NDRI, Karnal; ICAR-IARI, Delhi; RLBCAU, Jhansi and Dr RPCAU, Pusa) of degree programmes in agriculture and allied subjects, other than Veterinary Sciences, including the award of National Talent Scholarship (NTS) was held in online mode (CBT). The examination attracted 89,413 applications, out of which 61,051 candidates (68.27%) appeared for the examination conducted by NTA. Among the categories, OBC (NCL) candidates were highest (26,794) followed by General (15,455), SC (8,999), General EWS (5,043) and ST (4,760).

All-India entrance examination for admission to PG: Following ICAR's AIEEA 2021 (PG), online counseling for 26th AIEEA-2021 (PG) was completed and out of 3,119 seats available for admission; a total of 2,475 seats were filled from ICAR quota seats. Further, the 27th AIEEA (PG) 2022, online examination through NTA was conducted for admission to 25% seats (100% seats of ICAR-DUs; RLBCAU, Jhansi and Dr RPCAU, Pusa) in PG programmes including award of ICAR-PG scholarship. A total of 18,332 candidates (88.78%) appeared in the examination out of 20,648 applicants. Of these, the number of female candidates (9,025) was almost equal to the males (9,307). Among the categories, OBC (NCL) candidates were highest (6,842) followed by General (5,670), SC (2,889), ST (1,609) and General EWS (1,322).

All-India competitive examination for PhD admission and award of Junior/Senior Research Fellowship: Online counseling for 26th ICAR's AICE-JRF/SRF(PhD) 2021 was completed and a total of 1027 seats were filled out of 1350 available. Also, the 27th ICAR's AICE-JRF/SRF(PhD) 2022 was held through NTA for admission to 25% seats (100% seats of Dr RPCAU, Pusa and ICAR-DUs-4) in PhD programmes including award of fellowships. A total of

11,001 candidates (84%) appeared in the examination out of 13,097 applicants. Of these, the number of female candidates (5,757) was higher than that of males (5,244). Among the categories, OBC (NCL) candidates were highest (3,815) followed by General (3,787), SC (1,769), ST (831) and General EWS (799).

Award of fellowships

- **ICAR fellowships for post-graduate students**: 592 and 294 students were awarded ICAR-PG Scholarships and ICAR-JRF/SRF (PGS) for Master's and Doctoral studies, respectively.
- **Merit-cum-means scholarship:** During the year, 84 meritorious under-graduate students belonging to below poverty line families were awarded the scholarship.
- **Internship allowance** to 4,652 veterinary graduates trained by Agricultural/Veterinary Universities was provided.
- **National Talent Scholarship (NTS):** During the year 6,734 UG and 3,542 PG students were provided NTS.

Globalization of agricultural education

Netaji Subhas-ICAR International Fellowships: "Netaji Subhas-ICAR International Fellowships" for pursuing doctoral degree in agriculture and allied sciences in the priority research areas, is awarded to the (i) Indian candidates for study abroad in the identified overseas Universities/Institutions having strong research and teaching capabilities and (ii) to overseas candidates for study in the Indian Agricultural Universities (AUs) in the ICAR-AUs system. The aim is to create a pool of scientist-envoys for enhanced future co-operation. As per guidelines, 30 fellowships are available every year.

Out of 218 candidates selected during 2009-10 to 2020-22, 114 candidates have completed their PhD under this programme. Ninety nine candidates including 8 foreign national candidates are currently doing PhD in their identified universities. Six candidates have joined their host universities abroad during the period.

Promotion of excellence

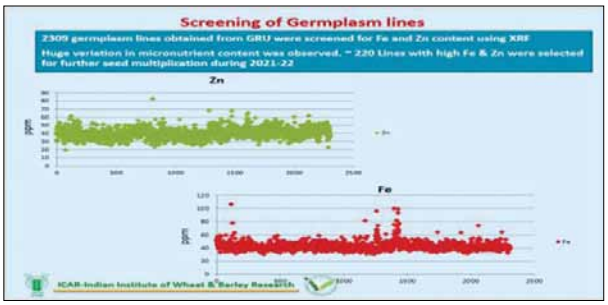
ICAR National Professor/National Fellow/ Emeritus Professor/Emeritus Scientist: ICAR supports National Professor with the twin objectives to promote excellence by recognizing outstanding scientists with proven output and outcome for creating a culture of basic research through their project work in the National Agricultural Research System (NARS) and establishing and nurturing a novel school of thought around the recognized person. During the period under report, 5 National Professors and 11 National Fellows were in position.

The aim of Emeritus Scientist and Emeritus Professor programme is to complete the on-going work for its fruitful conclusion; utilize their talent in teaching specialized courses, student research guidance; developing instructional material/textbooks including e-learning resources for use in National Agricultural Education Programme and distance education. In addition to research work, some Emeritus Scientists were engaged in teaching advanced courses at PG and Doctoral levels, guiding postgraduate students in their research pursuits, and publication of books and development of practical and teaching manuals. Currently, there are 24 Emeritus Scientists and 28 Emeritus Professors in position.

Salient research achievements

- *Identification of stable breeding lines for high grain iron and zinc concentration:* A set of 2309 lines of wheat germplasm obtained from Germplasm Resource Unit, ICAR-IIWBR, Karnal were multiplied for seed increase during the crop season 2021-22 and are being analysed for Zn and Fe content using Energy Dispersive X-ray fluorescence (ED-XRF). The core 218 lines having high Zn and Fe were further sent to Wheat Summer Nursery for seed increase at Dalang Maidan. The known QTLs were validated for grain iron and zinc concentration.
- Rajendra Genhu 3 (WB 02) and DBW 187 biofortified wheat were approved for area extension under irrigated, timely-sown conditions of Bihar and Central Zone, respectively.

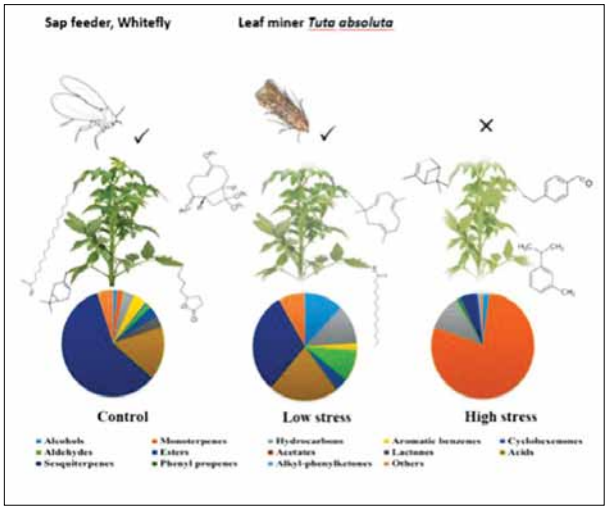
Multiplication at Summer Nursery at Dalang Maidan, Lahual Spiti



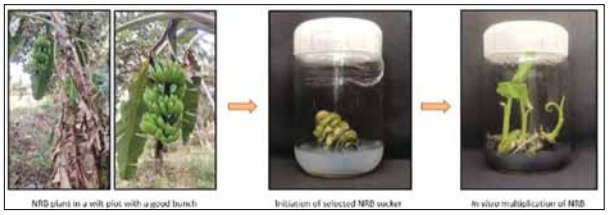
Screening of gemplasm lines

- The ecological and molecular basis of vector behaviour was explored and it was found that host volatile preference for non-viruliferous female whiteflies (*Bemisia tabaci)* was found to be preferentially oriented towards infected chilli plant [with chilli leaf curl (ChCLV)] volatiles, while viruliferous whiteflies preferred healthy chilli plant (*Capsicum annuum*) volatiles. The electrophysiological studies involving electroantennogram (EAG) assays exhibited similar trend in EAG response amplitudes. Transcriptome profiling of the viruliferous and non-viruliferous whiteflies and realtime qPCR validation showed differential expression of certain odorant binding proteins (OBPs) in viruliferous whiteflies.

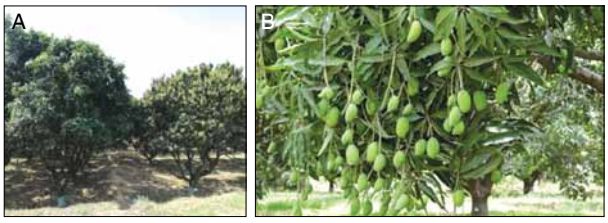
- Specific aromatic cues were identified from the ripe arils of jack fruit that showed attraction to both sexes of *B.dorsalis,* which can be used as a unisex lure for trapping fruit flies.
- The impact of low moisture stress on herbivore-plant interactions was studied using tomato and its associated herbivores (leaf-miner, *Tuta absoluta* and sap feeder, whitefly, *Bemisia tabaci*). The volatile emissions of tomato plants subjected to low moisture stress were found to alter its associated herbivore preferences and it was found to vary according to the herbivore feeding guild.



- *Management of phytophagous mites in apple orchards and poly houses:* Sampling of winter spurs for winter eggs of mites was conducted in apple orchards where management operations were undertaken in the previous year. Study reported 15 to 25% infestation of winter eggs in managed orchards, whereas in unmanaged orchards 60-70% spurs were infested with winter eggs of mites.
- Clones of banana with elite characteristics,10 Elakki banana selections and 25 Nanjanagudu Rasabale selections in terms of resistance to *Fusarium* wilt conditions (5 Elakki and 10 NRB selections) and a few clones showing valuable elite yield parameters (5 Elakki and 15 NRB selections) were used for proliferation. The collected suckers in different stages of multiplication were screened for disease resistance *in vitro* using Fusaric acid.



- The effectiveness of different doses (2-10 g a.i. per tree) of Paclobutrazol (PBZ) for promoting the flowering and fruiting in mango cv Dashehari was evaluated and was found to be very effective



Paclobutrazol use for regular cropping and avoiding decline in mango orchards. (A) Flowering behaviour under PBZ treatment, (B) Fruiting behaviour under PBZ treatment

for increasing the mango yield (25 to 60%) and improving grower return in orchards. HPLC and LC-MS/MS analysis of the residue in fruit did not show the presence of PBZ, showing its safety for consumption. Residual influence of PBZ in soil on fruit yield was observed, if applied continuously for two consecutive years only.The study showed a shift in soil microbial diversity due to the continuous use of PBZ in orchards. Metagenomic study revealed that the abundance of some of the bacterial groups increased, although the overall abundance of bacteria appeared to decrease in PBZ treated soil.

- *Dietary diversification and nutritional status of adolescents in rural-urban interface:* Prevalence of anemia among adolescent boys and girls was noted and among girls PCOS (Poly Cystic Ovarian Syndrome) was found to be the burning issue and it was addressed through nutrition education and intervention program.
- On the occasion of POSHAN MAAH-2021 and 2022, cookery competition on value-added products, lunch box concept and smoke-less cooking was conducted for parents, teachers, *anganwadi* workers in collaboration with NIPCCD (National Institute of Public Cooperation and Child Development) and KVK.

Imparting nutrition education to children

- *Conversion of pine needle pyrolysis oil into liquid biofuel:* Yield of crude, moisture free bio-oil from pine needles at optimum pyrolysis temperature of 500°C was found to be 220 g/kg of biomass having high heat value (HHV) of 29 MJ/kg.The crude pine needle bio-oil was refined by vacuum distillation process and thermal stability of diesel-

Raised bed mulching and drip laying machine

refined bio-oil blends containing 5,10,15,20 and 25% bio-oil was tested between 0 to 50ºC and was found stable.

- Raised bed mulching and drip laying machine with two row transplanting attachment was developed and its evaluation was done.
- Biomaterial-based hydrogels reinforced with cellulose nano-crystals developed using marine biopolymers and were assessed for tissue engineering and regenerative medicinal applications. Bilayer chitosan-alginate-poly vinyl alcohol scaffold was prepared and the biocompatibility tests revealed it's wound healing ability. Technology has been developed for the preparation of nano chitosan-based biomaterial incorporated with chlorhexidine.

Chitosan film as wound dressing material

- Developed serum based indirect plate ELISA using recombinant hypodermin C for diagnosis of goat warble fly disease. The patent for the recombinant hypodermin C based iELISA has been applied at Controller General of Patents, Designs and Trade Marks, New Delhi, India with the title "Diagnostic Kit For Goat Warble Fly Infection". (Application number 202111024154, Date: May 31, 2021).

Serum based ELISA kit for diagnosis of goat warble fly disease

- A total of 210 isolates of extremophilic cold tolerant microbes were procured from different localities of the cold desert of Ladakh and Kashmir valley. The prepared microbial consortia were used to evaluate their decomposing potential under *invitro*conditions on agricultural wastes at FoA,Wadura. Three microbial consortia are being used for *in vivo* experiments at Gurez and Ladakh.
- *Revival, conservation and exploration of rice biodiversity in temperate region:* Characterized local land races for physiochemical and cooking quality traits, aroma, Zn, Fe and amylose content. Screening of Wide Rice germplasm for cold tolerance at seedling stages of growth under controlled conditions at MRCFC, Khudwani.

Direct benefit transfer (DBT)

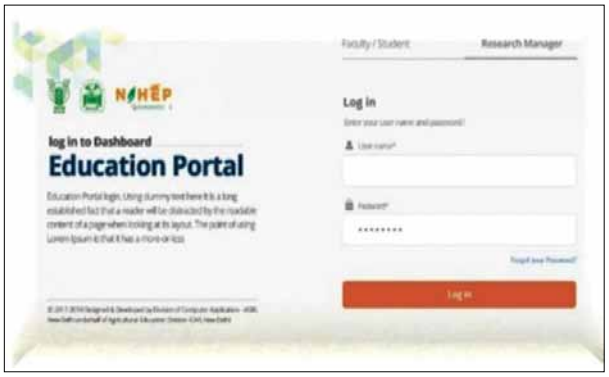
The notification of Netaji Subhas ICAR International Fellowship was done under Section 7 of the Aadhar Act along with other fellowships. The monthly progress report is submitted to DBT Bharat portal through web service.

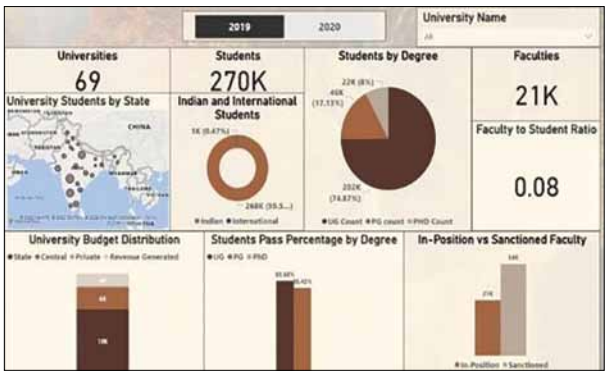
National Information System on Agricultural Education Network in India

The education portal is designed, developed and maintained by Division of Computer Application, ICAR-IASRI, New Delhi under the guidance of Agricultural Education Division, ICAR, New Delhi. This portal serves as a first touch point for all the 74 agricultural universities and students (aspirant or existing) for information, services, demand for funds and certifications. The education portal is a single platform consisting of information about all the agricultural universities, institutes, colleges, courses, events, circulars and publications. It also serves as an interface between the universities and ICAR for demands and grants, Student READY, scholarships and one stop platform for all IT resources for the universities. The universities can raise demands, and request for university and college student scholarships.

In last FY 2021-2022, the module for Student READY 'Rural and Entrepreneurship Awareness Development Yojana' was designed and developed to provide end to end automation for the Student READY program. The process flow-based control mechanism provides better transitions between workflow stages and streamlines flow of information between users. The application provides continuous up-to-date status and more accurate and easy reporting system. The implementation of USID (Unique Student ID) and UFID (Unique Faculty ID) was completed post correcting the existing duplicate USIDs through rigorous analysis of database and ETL (extract, transform and load) process. Developed database anomalies document with different anomalies in education portal database like inappropriate data types, incorrect USID, duplicate student data, wrong Aadhar card and many more and provided solutions. Major changes have been carried out in the database design

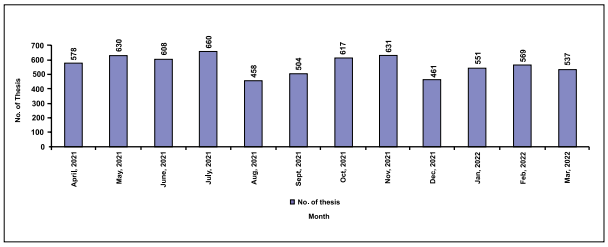
and schema to ensure cyber security. A more interactive Agricultural Education Portal 2.0 with improved user interface and experience was designed and developed. Various dashboards with quantitative insights, business intelligence and data representation/visualisation for different types of users such as research managers, university nodal officers and faculties were developed.





Information technology, digitization and library strengthening

A national digital repository for collection of valuable documents in the field of agriculture and allied sciences has been created and strengthened. Currently this digital repository (https://krishikosh.egranth.ac.in/) has 45 million digitized pages in 2,40,000 digital items (volumes) like old books, old Journals, reports, proceedings, reprints, research highlights, training manuals, historical records, which includes more than 1,08,000 theses digitized from various NARES Institutes/SAUs. Developed tools for 'important keywords' extraction along with its frequency in different years from the metadata of thesis titles available in Krishikosh repository. Frequency based keyword extraction technique is utilized to identify and quantify the prominent keywords/technology signifying the Govt. of India emphasis with respect to time frame. Based on this analysis, it indicates the numbers of research studies on prominent keywords/technology for which Govt. of India emphasis is increasing with time especially in MSc and PhD thesis program in various NARES organisations. Controlled Vocabulary solution–VocBench is a web-based, multilingual, collaborative development platform for managing OWL ontologies, SKOS(/XL) thesauri, Ontolex-lemon lexicons and generic RDF datasets. It's an open source and enterprise scale-controlled vocabulary/thesauri/Ontology solution that generally works as a back-end solution. This solution has been integrated with Krishikosh specific controlled vocabulary. Google analytics of Krishikosh during 1st April, 2018–31st March, 2022 indicates 11,266,929 hits, with India, United States, Sudan, Ethiopia, Russia, China being the top six countries who visited this digital platform. Krishikosh repository was viewed by 175 countries through various browsers, which also shows that this portal is independent of the browser platform and thus, can be viewed via any web portal system in the world. It is the single platform for exposing and sharing the intellectual outputs of NARES and provides 24×7 online availability of huge NARES content/ knowledge-base on a digital platform. The month-wise theses uploaded in this repository from April, 2021 to March, 2022 are given below. In addition, a total of 22 agricultural universities were supported under the library strengthening programme for print books, RFID and other library resources.



Month wise thesis uploaded in Krishikosh (April, 2021 to March 2022)

Infrastructural support for teaching and learning facilities

The support under the component 'Development and Strengthening' continued during the year. The ongoing new civil work of one auditorium was supported, in addition to 32 new skill development centres. The financial assistance was also provided for modernization and upgradation of the infrastructure pertaining to teaching and learning. Emphasis was on modernization of hostels, upgradation of laboratories, classrooms, etc. Teaching facilities have been further enhanced with additional support for 38 smart classrooms.

Computer lab

Smart classroom

Central Instrumentation Facility

Funding support also continued for AUs for conducting UG and PG practical and for various activities leading to holistic development of students. Across the country, AUs were continued to be supported to design and implement comprehensive quality improvement programs, capacity building of faculty, revision of course curricula, learning materials, processes, outcomes, assessment and monitoring systems, in order to ensure the quality of higher agricultural education.For increasing awareness in latest techniques and research in cutting edge areas, support was provided for student and faculty amenities/tours/capacity building and participation in seminars, symposia, workshops, trainings, etc. Overall personality development and leadership programmes with the support from the Council helped the students become better person and to grow as individuals.

The hostel facilities for the students have been improved with support from the Council. Placement cells helped students obtain placement or advice on career. Support from the Council was also provided to AUs to take necessary initiatives so as to encourage holistic development of students through sports, self-defence, yoga, personality development talks by eminent people, through workshops, coaching and counselling for clearing competitive exams on all India basis, etc.

Support under Schedule Tribe Component

The support under STC was provided to Agricultural Universities during 2022-23 for agricultural and allied activities in the tribal areas. A total of 23 Agricultural Universities were supported under the Tribal sub-plan for carrying out the mandated activities for the tribal population. 93 Training/ Skill development/Capacity building programmes were conducted benefitting 3854 tribals; 2677 demonstrations (FLDs/ OFTs) were done to promote awareness and were attended by 2915 beneficiaries. 8 Awareness camp/Exhibitions/Exposure visits were organized. 17,500 kg of inputs were supplied to about 4987 beneficiaries in form of quality seeds, planting materials, seedlings for various fruits, vegetable, small farm equipment, piglets, goats, poultry birds, etc. were given to tribal farmers to help them initiate the means to improve their livelihood. Small equipment needed for establishing backyard poultry and other related to honey bee rearing were also distributed to about 8873 beneficiaries. All these activities benefitted 21,262 stakeholders.

Support under Scheduled Caste Sub Plan (SCSP)

The support under SCSP component was provided to 43 AUs. This is an umbrella strategy started in the fifth and sixth plan by the planning commission to ensure flow of targeted financial and physical benefits from all the general sectors of development for the benefit of Scheduled Castes. Under this component, a total ₹2318 lakh was released to agricultural universities located in 15 states during. The support was provided for training and capacity building programme, viz. tutorials, classes, personality development, and preparation of competitive classes, entrepreneurship development and awareness programmes, funds for providing print books and access of e-books and other resources to the scheduled caste beneficiaries at college/university level. For the purpose of imparting skill and entrepreneurship, 32 skill training centres were supported during the year.

Support under North Eastern Hill Region (NEH)

During the year 2021-2022, ICAR through its scheme of Agricultural Education Division also supported the agricultural universities established in NEH Region for infrastructural development and also for new civil works with ₹3058 lakh. Among new civil works, 3 new

Agriculture Education Division	Unit	Achievement	No. of beneficiaries
• Training/ Skill development/Capacity building program conducted	Number	93	3854
• Demonstrations (FLD/OFTs) conducted	Number	2677	2915
• Awareness camp/ Exhibitions /Exposure visits organized	Number	8	633
• Input supplied [Planting material, intercrop input (seed, fertilizer), mineral mixture, distribution of masks, etc]	-	Number: 86234 kg: 17500	4987
• Other (Small farm equipment, Bio-agents, field bunding, backyard poultry, honey bee boxes, agriculture implements, etc)	-	Chicks: 2200 pic. Feed chick starter (50 kg): 50 bags. Feeder: 4 kg (100 pc) Water drinker: 4 litre (100 pc)	8873

student hostels, one for boys and other for girls both in Nagaland and one girls hostel in AAU, Assam; one Agri-business Incubation Centre at Medziphema; and 5 new smart classrooms were developed in various colleges of all the three AUs in NEH region. Laboratories have been modernized/upgraded and equipped with new equipment. Support was also provided for training and capacity building programs, viz. Tutorial and competitive classes, holistic development of students, library strengthening with additional print books, reference books, e-books, ICT tools and accessories and other logistics which has helped in better learning and advanced research. Execution of a major agro-ecotourism project under green initiative is underway. The process of entrepreneurship and skill development of the students was augmented through introduction of new/existing Experiential Learning Units and support for practical in form of contingency and research expenses enabling PG research and smooth conduct of practical's in both UG and PG degree programmes.

Coordination with AUs

To provide an opportunity to the Vice-Chancellors of AUs to interact with each other and develop strategy for effective functioning in order to maintain quality standards in higher agricultural education in the country as well as for effective implementation of the newer initiatives, 'The Conference of Vice Chancellors' was held during 12-13th April, 2022 and on 1st and 2nd September, 2022.

The Nodal Officers meeting was conducted at PJTSAU, Hyderabad, Telangana, on 1st and 2nd July, 2022. All the nodal officers were apprised of the recent steps and new initiatives taken by ICAR. The Education Division has identified various IT solutions and shared with the Universities in order to avail the available online options for the maximum possible components under the scheme.

The 75th year of independence of our nation is widely being celebrated as the *Azadi Ka Amrit Mahotsav*. To commemorate this monumental occasion, ICAR is organizing various events and campaigns in thematic areas of Indian Agriculture. Joining in this celebration, Agricultural Education Division is organizing '*Azadi Ka Amrit Mahotsava*' lecture series, and 75 lectures have been completed during this period.

National Agricultural Higher Education Project (NAHEP)

Indian Council of Agricultural Research (ICAR) commenced National Agricultural Higher Education Project (NAHEP) with the assistance of World Bank (WB) in November, 2017 with an overall objective to support participating Agricultural Universities (AUs) and ICAR in providing more relevant and higher quality education to the students. NAHEP endeavours increased agricultural productivity and supports quality improvements of higher education to create a more skilled workforce that continuously improves the productivity of key sectors, including agriculture. Overall, the project aims to develop resources and mechanism for supporting infrastructure, faculty and student advancement, and 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 and at par with the global agriculture education standards. Till March 2022, 62 Agriculture universities (AUs) have been awarded under NAHEP, wherein 22 AUs come under IDP, 16 AUs under CAAST and 24 AUs under IG in component 1. Besides, 2 ICAR institutes, i.e. ICAR-Indian Agricultural Statistics Research Institute (IASRI) and ICAR-National Academy of Agricultural Research Management (NAARM), has been implementing Component 2 of NAHEP.

Key provisions for funding 22 projects under IDP include students' skill and entrepreneurial development, enhancing learning outcome and teaching effectiveness, faculty development and training, networking and industry collaboration, vocational training, students' job placement, own revenue generation and support to the twinning plan. In addition to these priorities, emphasis is also being placed on effective industry linkages to enhance the employability of agriculture graduates as well as to help AUs to generate their own resources by establishing facilitative centres. Renewed public-private partnership efforts would also strengthen stakeholders' role in curriculum design, course evaluation and overall faculty and student development. More than 400 students and faculties have completed their international trainings in foreign institutions. During the period, IDP partner AUs have conducted more than 170 guest lecture series on entrepreneurship development trainings, established industry and institution linkages with more than 35 organizations, etc. Introducing AR/VR modules, establishing language proficiency lab, organizing interactions with alumni, and developing

Evidence of attribution of NAHEP grants leading to project outcomes (till March, 2022)

Indicators	Unit of measure	Baseline (2016-17)	Achievement
% increase in AU on time graduation rate	%	77	95.5
% increase in student placement rates	%	41	60.3
Reduced student inbreeding	%	19.2	25.3
Reduced faculty inbreeding	%	45	54.5
Improved AU revenue generation	%	8.5	12.4
Accredited agricultural universities with revised norms and standards	Number	55	71
Direct project beneficiaries	Number	-	3,56,302
Female beneficiaries	%	-	33

e-content modules are some of the out-of-box initiatives undertaken by IDP partner AUs during the period.

Under CAAST Component, 16 sub-projects have been awarded to AUs, spread across 11 states of the country. The major activities undertaken by AUs under the CAAST component include strengthening of teaching and research infrastructure; Distinguished Lecture Series/Special lectures to bring about much-needed vibrancy in the academic atmosphere and inspire students and faculties to perform better; National and international trainings for students, faculties and research scholars; Collaboration with private sector related to the specialized areas to develop market-oriented programs, etc. Till date, ~160 students and faculties have completed international trainings, whereas more than 4,000 national level trainings/seminars have been conducted to develop the scientific entrepreneurship of students and enhance research effectiveness. Development of climate-smart agriculture tools, innovative secondary agricultural technologies, and the establishment of innovative research labs are some of the out-of-box initiatives undertaken by CAAST partner AUs during the period.

IG projects have been awarded to select participating AUs to attain accreditation. Till date, 24 sub-projects have been awarded under this component. Key IG activities include national-level trainings for faculty upgradation, masters and PhD sandwich programs, alum linkages, industry seminars and professional workshops, and e-enabled learning activities, etc. It is worth mentioning here that, in the last three years, 11 AUs under the IG have attained ICAR accreditation due to NAHEP support and interventions.

Component 2 aims to support ICAR to carry out institutional reforms within ICAR and enhance its effectiveness in coordinating, guiding and managing agricultural higher education in the country. Till date, activities undertaken are strengthening key digital infrastructures of the ICAR-AU system, such as the establishment of virtual classrooms at 18 AUs and effective implementation of the Agri-DIKSHA web channel, which has more than 20,000 e-contents developed and uploaded by partner AUs, the establishment of AR/VR labs at 10 partner AUs, the launch of KVC-Alnet and facilitate the AUs for ensuring the alum registration (so far more than 43,000 alumni have been registered on the portal), etc. are some of the key initiatives undertaken by Component-2 of the project.

The major activities and achievements under the Monitoring and Learning component include Process Evaluation and Dipstick Surveys such as assessing the Graduate Income Index of 1-year graduate student, assessment of the measurable intermediate outcomes through mid-line survey specifically on facilitative units, development and implementation of AU Implementation Performance Scoreboard (AUIPS), satisfaction mapping of direct project beneficiaries, organizing M&E visits to select AUs, etc.

In addition, PIU has also taken various initiatives to enhance the learning outcomes, such as Waste to Wealth and linking entrepreneurship, Clean and Green Awards, KRITAGYA AgTech Hackathon, Promoting Resilient Agricultural Education System (RAES), and Strategic study to assess the requirement of human resources in agriculture and allied fields for next 20 years, etc. The infrastructure developed, teaching, learning and skill upgradation initiatives under NAHEP are very much aligned with the National Education Policy (NEP), 2020 formulated by the Government of India.

ICAR-National Academy of Agricultural Research Management (NAARM)

Research and Policy Advocacy: As a think tank of Indian Council of Agricultural Research (ICAR) in the field of agriculture, the Academy has been contributing policy briefs and documents on a wide range of issues of national and global importance, viz. Curriculum Development Framework for Agricultural Education, National Agricultural Higher Education Project – Component 2, FPOs in India: Creating Enabling Ecosystem for their Sustainability, Strengthening Kisan Call Centres in India, Attracting the best talent to agricultural education in India, Bioinformatics in Agriculture, Empanelment of Product Engineering Firms: Towards Co-Development of IT Solutions for Agricultural Sector Leveraging Private Sector Participation, Journey of a-IDEA in Shaping Agripreneurship Landscape in India and Guidelines for Incubators. Since November 2021, 44 research papers, 7 book chapters, 9 popular articles and 6 books were published. The 26th Institute Research Council (IRC) was conducted virtually on February 2nd and 3rd, 2022 and currently 17 in-House and 9 extra mural projects are ongoing at the academy. Three copyrights have been registered and 2 copyrights are filed. The third meeting

of VIII RAC was held at the academy during September 13-14, 2022.

MoUs entered with various institutions: The Academy signed several MoUs during the period from November 2021 to October 2022, viz. NCDEX Institute of Commodity Markets and Research (NICR), Dr YSR Horticulture University, University of Hyderabad and M/s Swarna Bharat Trust.

Memorandum of Agreements (MoAs) by a-IDEA of NAARM: Technology Business Incubator of NAARM a-IDEA has signed MoAs with many ICAR Institutes.With the objective of co-incubation and co-networking, a-IDEA entered MoA with 26 ICAR Institutes and 04 incubation centers.

List of MoUs signed by ICAR-NAARM

MoUs signed with NAARM	Date	Purpose
NCDEX Institute of Commodity Markets and Research (NICR)	11.11.2021	To promote skill development, knowledge, research, financial literacy in the commodity derivatives market space using modern interactive learning tools by providing trader training courses to the students/candidates.
Dr YSR Horticulture University	19.03.2022	For facilitating students training and post-graduate research.
University of Hyderabad	08.04.2022	For implementing the academic programmes on Education Technology Management and Technology Management in Agriculture.
M/s Swarna Bharat Trust	04.07.2022	To set up the general principles of collaboration between both parties, according to which the parties may jointly identify fields of mutual interest and create opportunities to develop programmes for cooperation in training, education and other knowledge-based activities on the basis of reciprocity and mutual benefit.

MoU with NCDEX Institute of Commodity Markets and Research

MoU with Dr YSR Horticulture University

Academics: The 12th batch of PGDM-ABM has successfully completed their 2-year residential programme at the Academy. All the 54 students of PGDM-ABM (2020-22) have been placed successfully in 20 reputed agri-business companies. The package offered ranged between ₹6.5 lakhs and ₹12 lakhs per annum (lpa) with an average CTC of ₹8.5 lakh per annum. During this period, a total of 57 students were admitted for 13th batch of PGDM-ABM. The academy also offers Post-Graduate Diploma in Technology Management in Agriculture (PGD-TMA) in which 29 students are pursuing the course. The Academy also initiated a new distance education programme on Post Graduate Diploma in Educational Technology Management (PGDETM) in collaboration with University of Hyderabad (UOH) in 2019. Out of 50 applications shortlisted, 25 candidates were admitted.

NAARM organized 4th Graduation Ceremony for its Post-Graduate Diploma in Management-Agri Business Management (PGDM-ABM) on 14th May, 2022. Chief Guest of the ceremony, Hon'ble Vice President Shri. M. Venkaiah Naidu awarded degree to 144 students belonging to four batches.

Training and capacity building: The Academy organized 80 capacity building programs during November 2021 to October 2022 benefitting about 8076 participants to cater diverse capacity needs of professionals of Research Management, Scientific, Technical and Administrative cadres of ICAR and Faculty members of Agricultural Universities (AUs). Academy offers Foundation Courses for the newly recruited faculty of SAUs to improve teaching, research and extension competencies.

Digital initiatives: Center for Open and Lifelong Learning in Agriculture at NAARM organized MOOCs in Education Management and developed more than 150 video-lectures. Total 21 modules of content have been developed for MOOC on Digital Teaching Techniques (9 videos) and MOOC on Digital Assessment and Evaluation Methodologies (13 videos) with interactivity. Since November 2021, Academy offered two MOOC programmes and benefitted about 3601 learners across the country.

Awards and recognition: ICAR-NAARM was awarded Sardar Patel Outstanding ICAR Institution Award 2021 (large institute category) by Shri Narendra Singh Tomar, Union Minister of Agriculture and Farmers Welfare under the broad category of National Awards of Excellence for Agricultural Institutions on ICAR foundation day celebration (July 16, 2022).

Start-ups and agripreneurship: The a-IDEA, ICAR-NAARM organized the launching ceremony of AGRI UDAAN 5.0 Food and Agribusiness Accelerator Programme on 06 August, 2022 with the support of NABARD. The programme was presided by Dr Ch. Srinivasa Rao, Director ICAR-NAARM, Hyderabad and Mr. Jayesh Ranjan, IAS, Principal Secretory, Department of Industries and Commerce, Government of Telangana. Road shows were conducted in four cities, i.e. Kolkata, Bengaluru, Delhi and Pune. National level ideation competition 'AGGNITE 2.0'was launched to motivate the students in entrepreneurship in agriculture and educate them on start-up ecosystem and entrepreneurship skill-sets. 40 applications were shortlisted from 114 applications received and finally 3 applications participated in the final winning. 'KRISHIBOOT' is an incubation program aimed to attract start-ups or individuals who are in the ideation/ early start-up stage to get incubated at a-IDEA. Out of 119 pan India applications received, 22 were selected in the final round for incubation and 14 on-boarded by signing MoU. The a-IDEA invited innovators working on innovative Idea/POC/Prototype stage to apply for 'NIDHI PRAYAS' grant of up to ₹10 lakhs in the field of agriculture and allied sectors.

❑

14. Social Science

Effectiveness of farmers' own risk management strategies: Farmers face multiple climate risks. They follow several measures, traditional and modern *ex-ante* and *ex-post* their occurrence to reduce their adverse effects. However, in the absence of a market for modern risk management measures like insurance, a majority of farmers relies on the traditional measures, including mulching, soil and water conservation, shifts in planting dates, input manipulations, diversification into low-risk, high-value crops and animal husbandry, non-farm employment and small-scale businesses, out-migration, borrowings, and sales of non- productive as well as productive assets. Using data from the Situation Assessment survey of the National Sample Survey Office (NSSO), 2012-13, and applying the Multinomial Endogenous Switching Regression, this study estimated the impact of different risk management strategies on farm productivity and its resilience to climatic shocks. Based on their risk functions, different measures were categorized into risk-mitigating, risk-transferring and risk-coping strategies, and further combined to evolve their portfolios. Risk mitigation is the most preferred strategy, followed by risk coping and risk transfer strategies.

The payoffs are higher to risk mitigation, followed by risk transfer and risk coping. Importantly, their joint adoption is more effective compared to any of these when implemented in isolation. Further, all the risk management strategies reduce farmers' exposure to downside risk (skewness), but their joint adoption has a larger effect. These findings suggest that the traditional agricultural practices are effective in improving not only agricultural productivity but also in reducing farmers' exposure to downside risk.

Productivity and risk benefits of crop insurance versus irrigation: The uptake of crop insurance in India remains low despite significant policy and institutional support. The *Pradhan Mantri Fasal Bima Yojana* (PMFBY) launched in 2016 had aimed at bringing at least half of the gross cropped area under insurance in two years, i.e. by 2018, yet the target remains unachieved—by 2020-21, only one-third of the gross cropped area was covered under crop insurance.

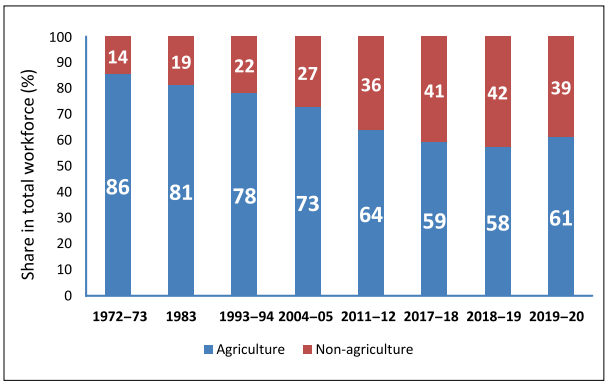
Several explanations have been put forth for limited crop insurance. However, farmers' decisions regarding the adoption of insurance depend on its expected gains in relation to gains from the risk mitigating measures such as crop diversification and irrigation. This study estimated productivity and risk effects of crop insurance *vis-à-vis* irrigation to explain the low uptake of crop insurance. Irrigation improves crop yields, and it also provides partial protection to crops from the climatic shocks. Crop insurance, on the other hand, reduces farmers' exposure to downside risk, i.e. the probability of loss in crop yield due to climatic shocks. The costs and expected payoffs of these measures also differ. Payoffs to irrigation are almost certain, while to crop insurance, these are highly uncertain as gains from insurance can be realized if crop yield falls below an administratively pre-determined threshold level. Crop insurance can also influence crop yield through its feedback on farmers' decisions regarding the adoption of improved technologies, inputs, and agronomic measures.

The productivity and risk benefits of crop insurance and irrigation were estimated in terms of their average treatment effects (ATTs), applying the Multinomial Endogenous Switching Regression to the data extracted from the Situation Assessment Survey of Agricultural Households conducted by the National Sample Survey Office (NSSO) of the Government of India in 2012-13.

Both crop insurance and irrigation positively impact farm productivity, but their gains differ significantly. The productivity gains from crop insurance are much less compared to that of irrigation, but these magnify when both are used in conjunction.

Likewise, both the measures reduce variability in farm income, but the effect of irrigation is twice that of crop insurance, and much larger in case of their joint adoption. Skewness is a better measure of risk; and a positive skewness means lower probability of crop failure. The risk benefits from using irrigation are almost twice of that from crop insurance, and the payoff is larger to their joint adoption. Nevertheless, the benefits of crop insurance and irrigation differ across rainfall regimes. At higher rainfall levels, crop insurance is as effective as irrigation. Conversely, the gains from irrigation far outweigh the gains from crop insurance at lower rainfall. The key implication is that to make crop insurance a substitute of irrigation, there is a need for considering the risk benefits of irrigation while pricing the insurance products.

Structural changes in rural employment: The structure of rural employment is undergoing a change. In 1972-73, about 86% of the rural workforce was engaged in agriculture. With economic development in general and rural development in particular, the rural employment started diversifying in the early 1990s; the share of agriculture in the rural workforce declined to 78%. The pace of employment diversification accelerated thereafter and between 1993-94 and 2004-05 employment in non-agricultural activities grew much faster than in agriculture. Interestingly, the agricultural workforce declined by about 34 million between 2004-05 and 2011-12. On the other hand, 28 million workers



Distribution of rural workforce between agriculture and non-agriculture

joined the non-agricultural sector during this period. This shows a preference for employment outside agriculture.

The withdrawal of agricultural workforce further accelerated, and an additional 28 million workers left between 2011-12 and 2017-18. This was accompanied by a slow-down in non-agricultural employment, leading to decline of 21 million in overall rural workforce. The share of agricultural workforce in the rural workforce fell to 59 % in 2017-18. The Period Labour Force Survey (PLFS) conducted during 2019-20 revealed a significant increase in rural workforce over 2017-18.

Irrigation water pricing and crop diversification in Punjab: This study assessed the feasibility of a uniform water pricing policy and a differentiated water pricing policy wherein farmers growing less water requiring crops get an incentive for saving the water, while those growing water-intensive crops pay for it. The findings show that groundwater resources cannot sustain further increase in gross cropped area. Under the existing water policy regime, optimal allocation of resources (land and water) to crops has limited scope to reduce area under rice and check groundwater depletion. Notable shift in cropping patterns will take place when a volumetric and differential water pricing policy is adopted. Area under rice will reduce by 23%, while area of maize and oilseeds will increase significantly.

Simulation of two alternatives for internalizing externalities through different volumetric water pricing policies produces a differential effect on water saving and overall agricultural income, suggesting compensating farmers for any adverse economic impacts. The findings imply the need for direct and visible incentives for crop diversification. As long as water is accessible, the tendency of its indiscriminate use will remain. The volumetric water pricing will also encourage efficient use of surface water.

Technology and policy options for reducing India's import dependence on edible oils: India heavily depends on imports to meet its edible oil demand. Enhancing domestic production capacity should help bring down import bills. The Government of India has taken several policy measures to promote oilseeds and edible oil production. The improvements in production technology and protective tariffs could be the instruments of choice. Possibilities of reducing import dependence by increasing domestic production, adopting yield-enhancing technologies, and raising import tariffs, were investigated.

A rise in TFP growth of oilseeds since the mid-2000s correlates well with an improvement in oilseeds production, signaling the impact of technological change reflected in improvements in productivity and production and its spillover effects. Higher tariffs, other than regulating imports, also protect domestic industries and farmers. The impacts of technological improvements in oilseeds are measured in presence of different levels of tariffs on edible oils using Standard Computable General Equilibrium (CGE) model calibrated to a Social Accounting Matrix (SAM) for 2017-18 to estimate the impacts on domestic oilseeds and edible oil production, rural income, and inflation.

Scenarios A and B provide the impacts of raising import tariff rates. Scenario A presumes that the tariff level is raised by 50% and it doubles in Scenario B. Scenarios C and D assume a moderate increase in total factor productivity (TFP) growth in oilseeds in the

Allied Activities - A Boost to Agricultural Growth

In the recent decade, the agricultural sector has experienced all-time high growth of 3.5%, and the growth has been driven by the animal husbandry and fisheries. During 2011-12 to 2019-20, the livestock and fisheries sub-sectors grew at 7.5% and 8.6%, respectively, while the growth in crop sub-sector decelerated to 1.5%, from 2.7% during the previous decade. The demand for animal-source foods has been growing faster than plant-based foods, suggesting that Indian agriculture has been experiencing a demand-driven diversification, which is expected to continue in the future because of the sustained rise in per capita income and growing urbanization. To sustain the growth in allied agriculture, there is a strong need for greater technological, institutional and policy support.

Growth in agriculture and allied activities (%)

Period	Crops	Livestock	Fisheries and aquaculture	Forestry and logging	Agricultural sector
1950–51 to 1960–61	3.0	3.0	5.6	0.5	2.8
1960–61 to 1970–71	1.9	1.8	3.9	3.2	2.0
1970–71 to 1980–81	2.1	2.0	2.7	-1.0	1.8
1980–81 to 1990–91	3.2	3.3	5.8	0.0	3.1
1990–91 to 2001–02	3.2	3.2	5.1	1.2	3.2
2001–02 to 2011–12	2.7	4.5	3.8	-0.6	2.7
2011–12 to 2019–20	1.5	7.5	8.6	3.5	3.5

presence of tariff hikes as in Scenarios A and B. The TFP experienced a growth of 1.5% after the mid-2000s, and it is assumed to grow at a rate of 2%. Scenarios E and F presume a higher rate of TFP growth of 3%. As a reference case, the trade liberalization is also studied in Scenario G.

The impacts are assessed on domestic oilseed and edible oil production, farm income, and general price level. The contribution of technology is stronger than that of tariff hikes. When the existing tariff rates are doubled, the imports of edible oil decline by 18%. Since it inflates edible oil prices, the oilseed prices also increase through the demand effect. Still, the response of production is low, only 1.7%, which, far below the requirement to compensate for the edible oil demand.

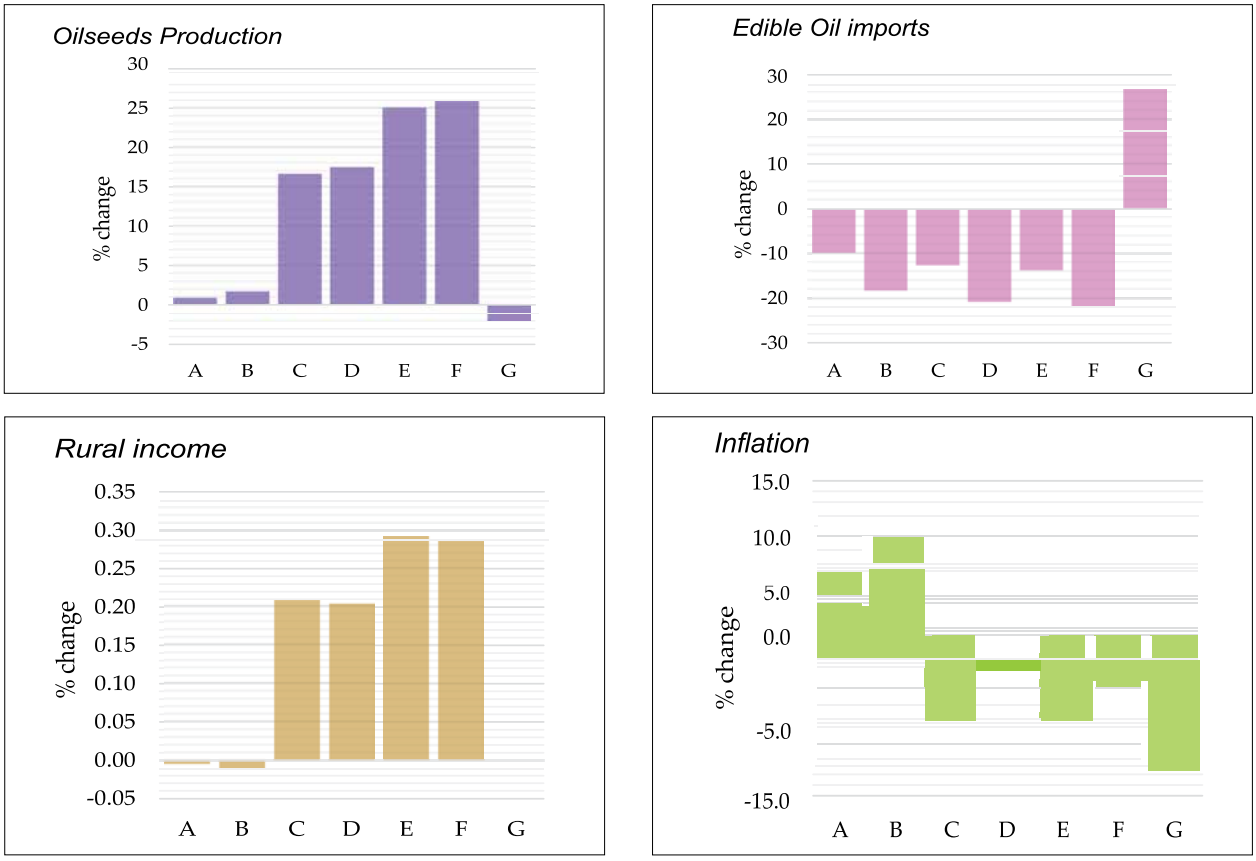
When the TFP grows at a rate of 2%, the oilseed production increases by 17% even after imposing higher tariffs. It also leads to a higher rate of reduction in the edible oil imports. As part of the production is consumed by the households, the marginal reductions are less. A greater response is observed in both the oilseed and edible oil production with TFP growth. TFP growth brings about a decline in prices even in the case of tariff hikes. Rural income also rises when production technology improves despite a fall in oilseed prices. The impact of removing tariffs on oilseeds works in the opposite direction. It leads to a surge in edible oil imports and fails to increase oilseeds production. Although the consumers benefit, the cost to the Government inflates, pushing up the fiscal deficit. Thus, tariffs could be an instrument to regulate edible oil imports but not to boost oilseeds production. To this end, an improvement in technology shall contribute significantly. Opportunities also lie in exploiting the yield gaps.

Statistical tools/Techniques

Row-column designs with two rows: A general method of construction of row-column designs with two rows for orthogonal estimation of main effects and two factor interactions in minimum number of runs was given for orthogonal parameterization. A catalogue of efficient row-column designs for 2^n ($2 \leq n \leq 9$) factorial in minimum number of replications was prepared. A general procedure of obtaining efficient w-optimal row-column designs in two rows for n-factors mixed level factorial experiments based on baseline parameterization was developed and a catalogue of w-optimal row-column designs in two rows for n-factors mixed level factorial experiment based on baseline parameterization was prepared.

Linear trend free designs for factorial experiments: A general method of construction of multi-level factorial experiments that are linear trend-free for main effects and few lower order interaction effects was developed. Using this method, a series of 3^n and 5^n designs for complete factorial experiments that are linear trend-free for all the main effects were developed.

Experimental designs for polycross trials: A series of polycross designs for v genotypes (where v+1 is a prime number) in v/2 squares of size v each



Impact of technology growth on selected macro-economic outcomes

and each genotype replicated $v^2/2$ times, balanced for neighbours in eight directions was obtained. Another series of polycross designs for v genotypes (where v is an odd number) in v arrays of size $(v+1)/2 \times v$ each and each genotype replicated $v(v+1)/2$ times, balanced for neighbours in 8 directions, was developed. Developed a general method of constructing a series of neighbour restricted row-column designs for polycross trials in v (=4m) genotypes with two groups having 2m genotypes each in m arrays of size $2 \times v$ each and each genotype replicated $v/2$ times. SAS Macros were developed to generate these three series of polycross designs. For easy accessibility and quick reference of polycross trials by the experimenters, an online software was developed.

Slice Latin Hypercube Designs (SLHD): Developed methods of construction for (i) SLHD with equal batch size; (ii) SLHD with unequal batch size; (iii) Orthogonal SLHD with equal batch size; and (iv) Orthogonal SLHD with unequal batch size.

Partially balanced t-designs: Developed two series of partially balanced t-designs using cyclic development of initial block(s) and their association with t-packing designs was demonstrated.

Strengthening web application for incomplete split plot designs: Web application of construction of incomplete split plot designs was updated and module on analysis of incomplete split plot designs with completeness at main plot level and/or subplot level is made available at http://drsr.icar.gov.in/ispd.

Alternative sampling methodology for estimation of area and production: An alternative sampling methodology for estimation of area and production of horticultural crops developed by ICAR-IASRI under CHAMAN project, accepted by Ministry of Agriculture and Farmers Welfare, Government of India for adoption in all the states of the country is adopted by Department of Horticulture, Government of Haryana under the Technical Guidance of ICAR-IASRI and estimates of area and production of horticultural crops are being generated using this methodology since 2019-20 onwards.

Prediction model for GIGANTEA Protein: Developed a support vector machine-based prediction model for predicting GIGANTEA proteins in plants. Based on the developed methodology, a prediction server GIpred was established which is freely accessible at http://cabgrid.res.in:8080/gipred/ for proteome-wide recognition of GIGANTEA proteins.

Machine learning-based models for identification of abiotic stress responsive miRNAs: Developed machine learning-based models for identification of abiotic stress responsive miRNAs and Pre-miRNAs in plants, where the algorithms such as support vector machine, random forest, extreme gradient boosting and adaptive boosting were employed coupled with K-tuple nucleotide compositional features as numeric descriptors. Based on the proposed approach, a prediction server ASRmiRNA (http://cabgrid.res.in:8080/asrmirna/) for the identification of miRNAs and Pre-miRNAs associated with the abiotic stress response of plants was also established.

Computational model for identifying genes responsive to six abiotic stresses: Developed a computational model for identifying genes responsive to six abiotic stresses viz. cold, drought, heat, light, oxidative, and salt. The predictions were performed using the machine learning models viz. support vector machine, random forest, extreme gradient boosting and adaptiveboosting, where the autocross covariance (ACC) and K-mer compositional features were used as input. ASRpro, is made freely available (https://iasri-sg.icar.gov.in/asrpro/) for predicting abiotic stress-responsive genes and proteins.

Computational Model for Discovery of DNA Binding Proteins in Plants

Developed a novel computational model for discovery of DNA binding proteins in plants (PlDBPred) that play crucial roles in numerous cellular processes. Majority of the existing computational techniques for identifying DBPs are mainly applicable to human and mice datasets. It is a comprehensive machine learning based computational modelfor plant specific DBPs identification. The proposed model achieved highest repeated five-fold cross-validation accuracy of 94.0% AUC-ROC and 93.5% AUC-PR. The developed prediction server PlDBPred is publically accessible at https://iasri-sg.icar.gov.in/pldbpred/.

Machine learning approach to profile miRNAs from RNA-seq data (miRbiom): Formation of mature miRNAs and their expression is a highly controlled process. It is very much dependent upon the post-transcriptional regulatory events. Deciphering of conditional networks for these RBP-miRNA interactions may help to reason the spatio-temporal nature of miRNAs which can also be used to predict miRNA profiles. The miRNA profile prediction system has been implemented as a webserver available at https://scbb.ihbt.res.in/miRbiom-webserver/. Also its standalone version is available at Github (https://github.com/SCBB-LAB/miRbiom).

Gene regulatory network for rice blast disease: Study of gene regulatory network (GRN) helps in understanding complex biological processes. Inferring GRN is very challenging task as it involves computationally complex steps. The consensus GRN was constructed using Fisher's weighted method which combines the results obtained from correlation, principal component regression (PCR), partial least squares (PLS) and ridge regression-based scoring methods. The consensus GRN was constructed using the gene expression datasets of rice leaves under blast infected condition to understand the resistance mechanism in the crop that occurs during blast fungus infection. Differentially expressed genes (DEG) were identified

using one-way analysis of variance (ANOVA). The DEGs were considered for computing pair wise connectivity score using correlation, PCR, PLS and ridge regression. The significant edges were combined by Fisher's weighted method. The 74 significant edges and 40 nodes (genes) were found in the consensus GRN at 1% level of significance with 8 degrees of freedom of chi-square distribution. The evaluation of GRN was performed using Hamiltonian distance-based criteria, hub genes in the network and QTL analysis. The performance of consensus GRN is better than the individual methods correlation, PCR, PLS and ridge regression. The consensus GRN construction combining the results obtained from correlation, PCR, PLS and ridge regression will be helpful for biological research for understanding pathways of diseases. An interactive and user-friendly web tool was developed for consensus GRN construction. The web tool can take gene expression data as input and the output results are provided as in downloadable format in result window. The interactive web tool can be very useful and less time-consuming for constructing GRN.

Comparative publication citation analysis

- Citation analysis of publications during 2007-2020 was performed using the data retrieved from Web of Science {(SCI-Expanded: http://webofknowledge.com}. The comparisons were made for number of citations during (i) 2007-13 and (ii) 2014-2020: It was observed that from 2007-13 to 2014-20, the total (i) number of publications of ICAR increased to 20381 in 2014-20 from 12596 in 2007-13; (ii) total citations increased to 99318 in 2014-20 from 40343 in 2007-13; (iii) average citation per paper increased to 4.873 in 2014-20 from 3.203 in 2007-13; (iv) impact factor per paper increased to 1.707 in 2014-20 from 1.41 in 2007-13; (v) number of papers in journals with impact factor ≥4 increased to 68 in 2014-20 from 37 in 2007-13 and (vi) number of papers in journals with impact factor ≥10 increased to 1958 in 2014-20 from 862 in 2007-13.
- For 2017-20, comparison based on 500 most cited Papers each year (Total of 2000 Publications) on the basis of data retrieved from Science Citation Index-Expanded revealed that (i) citation per paper for 500 most cited papers per year for ICAR is 18.18, whereas for EMBRAPA, Brazil it is 15.07 and (ii) Publications ≥50 citations for ICAR, it is 103, whereas for EMPRAPA, Brazil, it is 67.

Improved identification of splice sites incorporating secondary structure features: Developed a machine learning based prediction algorithm through which the splice site prediction accuracy can be improved in plant species by incorporating the secondary structures of the nucleotide sequence. For this, the support vector machine was employed for splice site recognition in *Arabidopsis thaliana,* which is a model plant species. The prediction accuracies were also evaluated with other machine learning methods such as Logit Boost, Random Forest (RF), AdaBoost and XGBoost. The prediction accuracies of SVM, AdaBoost and XGBoost were observed to be at par and higher than that of RF and LogitBoost algorithms. All the computer programming codes written in R are available at https://github.com/meher861982/SSFeature.

Citation Analysis of ICAR Publications

The comparative analysis of ICAR publications during 2017-20 (4 years) in Science Citation Expanded List 2017-20 with publications of CAAS, China; EMPRAPA, Brazil and CSIRO, Australia was performed. It was observed that for (i) ICAR: Total Publications in Science Citation Index-Expanded: 12481; Total Impact Factor: 22521.446; Citations per Paper: 4.52; h-index: 61 and Impact factor per paper: 1.80, (ii) CAAS, China: Total Papers in SCI-E: 18447; Total IF: 69069.413; Citations per Paper: 7.88; h-index: 85; Impact factor per paper: 3.74, (iii) EMBRAPA, Brazil: Total Papers in SCI-E: 7278; Total IF: 17380.495; Citations per Paper: 5.58; h-index: 55; Impact factor per paper: 2.39, and (iv) CSIRO, Australia: Total Papers in SCI-E: 13487; Citations per Paper: 13.02; h-index: 122.

R-packages for statistical modelling, image analysis, design generation, etc.

EEMDSVR: Ensemble Empirical Mode Decomposition and its Variant Based Support Vector Regression Model (https://cran.case.edu/web/packages/EEMDSVR/).

GreyModel: Fitting and Forecasting of Grey Model (https://cran.r-project.org/web/packages/GreyModel/index.html).

tsfngm: Time Series Forecasting using Nonlinear Growth Models (https://cran.r-project.org/web/packages/tsfngm/index.html).

LARGB: Leaf Area Determination from Visual Image (https://cran.r-project.org/package=LARGB).

FWRGB: Fresh Weight Determination from Visual Image of the Plant plant (https://cran.r-project.org/web/packages/FWRGB/index.html).

eemdARIMA: EEMD Based Auto Regressive Integrated Moving Average Model CRAN. R-project.org/package=eemdARIMA

NBBDesigns: Neighbour Balanced Block Designs (NBBDesigns) Version 1.0.0 (https://cran.r-project.org/package=NBB Designs).

mkssd: Efficient Multi-Level k-Circulant Supersaturated Designs (https://cran.r-project.org/web/packages/mkssd/index.html).

WaveletRF: The Wavelet Decomposition followed by Random Forest Regression (RF) models were applied for time series forecasting, at https://CRAN.R-project.org/package=WaveletRF.

mxkssd: Efficient Mixed-Level k-Circulant Supersaturated Designs at https://cran.r-project.org/web/packages/mxkssd/index.html.

iRoCoDe: For the generation of the row-column design (https://cran.r-project.org/web/packages/iRoCoDe/index.html).

TSANN: Time Series Artificial Neural Network (available at https://CRAN.R- project.org/package=TSANN).

TSLSTM: Long Short Term Memory (LSTM) Model for Time Series Forecasting (https://CRAN.R-project.org/package=TSLSTM).

WaveletSVR: Wavelet-RF Hybrid Model for Time Series Forecasting (https://CRAN.R-project.org/package=WaveletSVR).

EpiSemble: Ensemble Based Machine Learning Approach for Predicting Methylation States (https://CRAN.R-project.org/package=EpiSemble).

OptiSembleForecasting: Optimization Based Ensemble Forecasting Using MCS Algorithm (https://CRAN.R-project.org/package=OptiSembleForecasting).

VMDML: Variational Mode Decomposition Based Machine Learning Models (https://cran.r-project.org/web/packages/VMDML/index.html).

vmdTDNN: VMD Based Time Delay Neural Network Model (https://rdrr.io/cran/vmdTDNN/).

Auto-Weather-Indices: Calculating Weather Indices from weather variables (https://cran.r-project.org/web/packages/AutoWeather Indices/AutoWeatherIndices.pdf).

pRepDesigns: Collection of several utility functions related to p-Rep designs (these designs are useful for early generation breeding trials are to be conducted in and multiple environments). https://cran.r-project.org/web/packages/pRepDesigns/index.html.

Biological databases

BSCM2TDb, a database on water buffalo that contain the data generated from differential DNA methylation extracted from MeDIP-seq data (ICAR-CIRB, ICAR-IASRI, ICAR-NRCE).

***BtChiLCVDb*:** *Bemisia tabaci* Asia II 1 transcriptome database in response to chilli leaf curl virus and is an online relational database of silverleaf whitefly (*Bemisia tabaci*) transcriptome (ICAR-IARI and ICAR-IASRI).

SCMVTDb: Transcriptome-based Mosaic Virus Database in small or green cardamom that contains the information of differential expressed genes, microsatellites, variants, transcriptional factors, pathways, domain and families (ICAR-IISR and ICAR-IASRI).

ParkRoxTDB: Tree Bean (*Parkia roxburghii*) Transcriptome Database is an online relational database of cucumber transcriptome (http://backlin.cabgrid.res.in/parkroxtdb/).

SIReDAM: Systematic Information Resources for Dairy Animal Management is a dedicated Management Information System (MIS) for bovines (http://webtom.cabgrid.res.in/SIReDAM/).

Levidb: Genomics of Virus in Legume Crops is a Viral diagnostics of legume crop (http://webtom.cabgrid.res.in/levidb/).

Millet SSR: This computational tool stores catalogue of microsatellites fetched (http://webtom.cabgrid.res.in/millet_ssr_db/) from Pearl Millet, Fox Millet, Proso Millet and Sorghum Millet genome.

PMDlncRDB : Pearl millet lncRNAs database is a web genomic resource, Pearl millet lncRNAs database.

LncR-CsExSLDb: LncRNA based Extended Shelf-Life Database for predicted lncRNA and circular RNA in cucumber (*Cucumis sativus*) transcriptome (in association with ICAR-IARI).

OYVMVTDb: Okra (*Abelmoschus esculentus*) Yellow Vein Mosaic Virus Transcriptome Database (in collaboration with ICAR-IARI and ICAR-NIPB).

EqSNPDb: Equine SNP marker database (in collaboration with ICAR-NRC-on-Equines).

CerealESTdb: (http://cabgrid.res.in/CerealESTDb), an interactive database to provide information on assembled and annotated ESTs from four major crop plants, namely wheat, rice, maize, and sorghum.

TiGeR: *Tilletia indica* genomic resource freely accessible at http://backlin.cabgrid.res.in/tiger/.

DeepAProt: Abiotic stress protein classification tool using Deep Learning in cereal freely accessible at http://login1.cabgrid.res.in:5000/.

BuffGR: Web genomic resource of buffalo accessible at http://backlin.cabgrid.res.in/buffgr.

ASRB-Online Application and Scorecard Information System (ASRB-OASIS)

ASRB-OASIS application (http://www.asrb.org.in/) was developed for inviting online applications for the RMP positions at ASRB level. System has the provision to auto-compute the scores based on information filled for different positions. Applications were invited online for various RMP positions (DDG/ADG/Directors) using this system. System was also developed for inviting application for Non-RMP positions.

Information Systems/Portals/MobileApps

- **IVRI Online Vet Clinic App** was developed by ICAR-IASRI in collaboration with ICAR-IVRI. The app is targeted to impart knowledge and skills to Graduating Veterinarians & Field Veterinary Officers about most frequent clinical conditions encountered in field conditions related to medicine. id=com.icar.ivri.iasri.veterinaryclinicalcareapp.
- **Strengthening Academic Management System (AMS):** AMS is a web-based application that is aimed at automating administrative and academic activities of agricultural universities to enhance the efficiency of the overall system by saving time and efforts involved in manual processes. AMS has been adopted in 56 agricultural universities and is reaching to around 65,351 students and 11,248 faculty registered in AMS. https://auams.in/
- **Virtual Reality (VR)/ Augmented Reality (AR) Experience Labs-**Under NAHEP–Component 2,

Augmented/Virtual Reality (AR/VR) Experience Labs are established at 10 agricultural universities to promote experiential learning through emerging technologies in agriculture and strengthen the agricultural education system through digital interventions. These labs allow to harness the power of digitally created environments for real time experience through AR/VR kits. This increases the ability to learn through virtual memory, enhance learning experience, explain abstract and intricate ideas easily, increases the level of engagement and provides inclusivity for the people of special needs. So far 14 modules have been developed under this activity.

- **Strengthening Virtual Classroom and Agri-DIKSHA Agri Web Channel:** Virtual Classrooms were established to enhance the teaching-learning experience across 58 agricultural universities. Now, all AUs are having network of Virtual classrooms to allow students to access high quality recordings of live lectures anytime and anywhere. The advanced content management for virtual classrooms is done on Agri-DIKSHA platform. This platform provides the faculties to record lectures, screen casting, video streaming and video content management. A virtual classroom is a system that provides the same opportunities for teaching and learning process, beyond the physical limits of the traditional classroom's walls. It does not require third-party editing tool. They have quick access to the video repository which can be accessed from desktop/PC/laptop/tablet/smartphone. More than 3000 hours of content was recorded and uploaded by the faculties across agricultural universities on this platform.
- **Strengthening KRISHI MEGH:** Under NAHEP, various digital initiatives are established and planned for future implementation to enhance the teaching learning experience and strengthen the overall agricultural education system. Data Centre (DC) at ICAR–IASRI and Data Recovery Centre (DRC) at ICAR–NAARM have been established to support these ongoing and planned digital initiatives. These establishments are jointly known as Krishi Megh. Krishi Megh provides cloud ready multilayer physical and information security infrastructure to agricultural universities. It is further strengthened to provide uninterrupted services to run digital initiatives smoothly, efficiently and effectively. The total storage was increased from 293 TB to 2006 TB, Total cores have been increased from 1138 to 1761, RAM has been increased from 5087 GB to 7107 GB and the physical nodes have been increased from 15 to 19.
- **WIAYFS (Weather Indices based Automated Yield Forecasting System):** A WIAYFS web tool was developed. Stepwise regression model based on weather variables in this model along with other models such as ARIMAX, LASSO regression, Bayesian Regression model and Random Forest technique have been implemented in this webtool. The URL for webtool : http://wiayfs.icar.gov.in/wiayfs
- **Infographics/Dashboard KRISHI Portal:** Developed (i) framework for graphical and table display on dashboard for data status for publications, technologies, video, audio, mobile apps, geo-metadata, copyrights, patents, registered varieties and varieties developed available in open access. The module of exporting all details of Dashboard to CSV file was developed; (ii) User Profile for each of Scientists consisting of information on publications along with NAAS score, technologies, varieties developed and IPRs (Copyright, Patent and Registered Variety with PPVFRA); (iii) Institute Profile has also been created for each of ICAR Institutes consisting of all above fields along with Video, Audio, Mobile App, Images information submitted by the Institute along with Institute address, Web address and Social Media Address.
- **ICAR Image Gallery:** Workflow based application for ICAR Image Gallery was developed in spring boot CAS enabled system and deployed on server. Officer Incharge, Data Management can upload single/multiple images with delete and set thumbnail options for one image per event. The records can be filtered on the basis of SMD, Organization and keyword. Search can also be made based on Keyword, date of event and description of image.
- **Module on Trademark and IPR Design:** ICAR-IASRI in association with IPTM Unit, ICAR Hqrs developed a workflow based application for Trademark and Design obtained by ICAR Institutes as Part of ICAR IPR Repository. At present, information on 122 trademarks and 58 IPR design is available in this repository.
- **CMS based Websites of AICRPs:** Developed websites for following 02 new AICRPs with uniform formatting and contents using Content Management System and different level user authentications: (i) AICRP on Linseed: launched by Dr. TR Sharma, DDG (Crop Sciences) in the Annual Group Meeting of Safflower and Linseed organized by by ICAR-IIOR on 18 August 2021 and (ii) AICRP on Sesame and Niger.

FARM WOMEN EMPOWERMENT

ICAR-Central Institute for Women in Agriculture (CIWA), Bhubaneswar carries out action research programmes on diverse aspects related to women in agriculture. Various research and extension activities are carried out through in-house, inter-institutional, network,

List of MoUs signed

Type	Signed Between	Date	Work
MoU	CSIR-National Botanical Research Institute, Lucknow and ICAR-IASRI, Pusa, New Delhi	07.10.2022	For genomic data analysis generated on cotton crop related with boll weight QTL for cotton yield improvement.
MoU	Association of Innovation Development for Entrepreneurship in Agriculture Centre for Agri-Innovation (a- IDEA) ICAR-NAARM, Hyderabad and ICAR-IASRI, Pusa, New Delhi	08.07.2022	To co-operate for accessing the laboratory and infrastructure facilities and mentoring under the incubation program of a-IDEA, NAARM. It aims to promote entrepreneurship in agriculture and allied sectors.
Contract Agreement	ICAR-IASRI, Pusa, New Delhi and M/s HyperRelity Studio Pvt. Ltd.	11.10.2022	The Supply, Installation and Commissioning of Hardware and Software for Virtual Reality (VR)/Augmented Reality (AR) and Design & Development of VR/AR based Learning Modules.

Copyrights received

Name	Dairy number	Registration number	Applied date	Received date
Flexible length B-Cell Epitope Prediction for FMDV (FlexiBef)	18522/2020-CO/SW	SW-14069/2021	17.11.2020	28.03.2022
Vigna mungo Transcriptome database VmTDB	26754/2021-CO/SW	SW-15268/2022	08.11.2021	24.03.2022
Unifying easy FDRs and SSR-FDMs Database Plant SSRDb	26748/2021-CO/SW	SW-15266/2022	08.11.2021	28.03.2022
Levidb: Genomics of Virus in Legume Crops	26751/2021-CO/SW	SW-15267/2022	08.11.2021	28.03.2022

collaborative and coordinated modes of research. During the year, ICAR-CIWA carried out research activities focusing on farm women nutritional security, livelihood enhancement, technological empowerment, drudgery reduction and entrepreneurship development. The salient achievements are as follows:

Participation and contribution of women in agriculture: Participation and contribution of women in agriculture and allied sectors were analysed using data from Census 2011, NSS 68th Round Survey and Time Use Study (TUS) 2019. The study makes a distinction between 'participation' and 'contribution' in agriculture. While participation denotes being involved or not, contribution quantifies the degree of participation using time devoted to an activity. Participation and contribution in agriculture both were calculated from the TUS-2019 data whereas, others give only participation. Based on analysis of unit level data of TUS-2019, it was revealed that in rural areas the participation (in per cent) of women (6yr + age) in agriculture (overall), crop sector only and livestock sector only were 22.36, 13.33 and 10.69, respectively whereas, the contribution were calculated to be 30.8, 27.2 and 45.8%, respectively. The participation and contribution in agriculture by women were calculated for all the states and UTs of India. Similarly, the relative participation of women (remaining being men) in agriculture (overall), crop and livestock sectors was calculated as 38.7, 31.1 and 49.1%. A large variation was observed among states/UTs both in participation and contribution by women. The participation of women (in per cent) in agriculture (overall) was highest in Himachal Pradesh (46.4), followed by Rajasthan (38.6) and Nagaland (37.5). In livestock sector, the participation of women (in per cent) was highest in Himachal Pradesh (39.3) followed by Rajasthan (29.4) and Uttarakhand (26.3). In eight states/UTs, the contribution of women in agriculture (overall) was more than 40%. In livestock sector, the contribution (in per cent) of women was highest in Himachal Pradesh (70.9) followed by Gujarat (61.0).

Drudgery reduction and vulnerability: Drudgery assessment of farm women in different Agro Ecological Regions -AER- of India revealed clusters of districts with high, medium and low level of Farm Power Availability (FPA). The clusters with high FPA (>2.03 kW/ha) belong to the region of agriculturally favourable (AERs) in Indo-Gangetic plains, Bengal basin, Kathiawar peninsula, Deccan plateau, Narmada, Tapi, Mahanadi, Godavari, and Krishna river delta. These clusters either had a perennial flowing river through it or were situated on a river delta with good quality alluvial, black clayey soil. All these factors lead to farmer taking multiple crops during a year, thus utilising mechanical means for timely farm operations. On other hand, clusters with low FPA (<1.00 kW/ha) belong to the region of agriculturally unfavourable AERs in Western & Eastern Himalayas; Malwa plateau, Eastern plateau, Bundelkhand plateau; Western plains, Assam plains, North Bengal plains; and North-east hills. All these factors cause low net sown cropped area and lower cropping intensity. Hence, the FPA in these clusters was low. The clusters with medium FPA (1.00 – 2.03 kW/ha) fall in portions of AERs that had a mixture of the favourable and unfavourable features, resulting in moderate agricultural needs. Assessment of drudgery in post-harvest activities of fisheries sector indicated that this sector was dominated by women as evidenced by their roles of cleaning, grading, processing and fish farming. Fish processing includes all activities from fish harvest until it reaches the consumer. Fish vending and processing are very tedious work and requires constant squatting or bending posture. Fisher women face constraints in fisheries

sector in various aspects like production, technical, economic, social, infrastructure, marketing etc. The major constraints faced are lack of water source, high cost of technology, lengthy and cumbersome procedure of getting credit, poaching, inadequate information to the beneficiaries, lack of special market etc. Under the farm mechanization component, the drudgery of women farmers in the selected cropping pattern (Rice + pulses + vegetables) was identified. The perceived rate of exertion by farm women in the selected cropping pattern by using Borg scale (Rating 1–10) revealed that more than 95% had exertion range of 6–9 indicating hard work in case of uprooting, thinning, weeding, ridge making, transplanting, harvesting, threshing and winnowing. In rice cultivation, 69% time was saved by using conoweeder and dry land weeder. Similarly, 68% saving in time was observed by use of seed treatment drum and mandwa weeder for seed treatment and weeding.

Gender sensitive agri-nutrition: Under gender sensitive agri-nutrition project, a survey was carried out to understand the change in knowledge level of farm women on nutritional aspects. With the capacity building programmes organized and the interventions made, the nutritional awareness among farm women increased to 60% as compared to the pre-project status of 15.5%. With the distribution of quality planting material and capacity building programmes, the preferences about horticulture crops was changed in the two villages. The women farmers now prefer to cultivate *Colocasia* followed by cowpea, followed by bitter gourd, okra and ivy gourd. A pan-India nutri-smart village project was designed with the objectives for promoting nutritional awareness, education and behavioural change in rural areas involving farm women and school children, harnessing traditional knowledge through local recipes to overcome malnutrition, implementing nutrition sensitive agriculture through homestead agriculture and nutri-gardens. Four districts namely Puri, Khorda, Cuttack, Jagatsinghpur were selected, from these districts, 7 blocks were randomly selected. From the selected blocks, 10 villages i.e. Kunjar, Mahura, Gadasanput, Nuagaon, Sankilo, Tentalapur, Kanjia, Sribanapur, Chitra, Sagada where technological interventions are being made.

Women entrepreneurship and skill enhancement: When women are facilitated with equal access to technology, inputs and services, they have the capability to generate strong economic outcomes through their enterprises. Up-scalable entrepreneurship models for rural women pertaining to small scale poultry, livestock and value addition of fish is the need of the hour. In a pilot study undertaken in Odisha to understand the institutional participation of women in dairy sector, it was found that out of the milk unions in Odisha, the highest number (462) of Women Dairy Co-operative Societies (WDCS) were under the Cuttack milk union and Ganjam district had the least number of WDCS (10). Institutional participation of women need to be emphasised more as women cooperatives facilitate in enhancing their skills and knowledge through extension activities, streamline the channel of milk marketing and safeguard them from exploitation.

Technological backstopping, development of entrepreneurial skills, facilitation in obtaining legal licenses and financial and market linkage are crucial in developing rural women agriprenuership. Potential women entrepreneurs were selected from eight blocks of 6 districts of Odisha after identifying their needs and constraints. Capacity building of the rural women in the aspects of intensive rearing of improved poultry breeds, scientific goat farming using low cost feed and housing methods and production of innovative value added fish products was done taking into account their interest, availability of resources and market potential of the products. Twenty eight capacity building programmes were organised in the identified areas which benefitted 902 rural women. Furtherance in development of women entrepreneurship was done through facilitation with critical inputs like improved breeds of goat and poultry, accessories for small scale poultry units, processing and packaging machineries etc. Business economics for the enterprises were also worked out. The women will work as individual entrepreneurs, or cluster units or Women Farmer Interest groups as per the selection of the enterprise. As market linkage is most important for ensuring the sustainability of any enterprise, the same was initiated by liaison with State Department agencies like, Mission Shakti, ORMAS, OPALFED and private retail chains like Falcon Fresh.

All India Coordinated Research Project (AICRP) on Women in Agriculture: ICAR-CIWA, AICRP Centre, PAU, Ludhiana developed non-woven and woven paddy straw mulch mats for moisture conservation in the fruit orchards and pots. Experiments were conducted in collaboration with College of Horticulture and Forestry, PAU, Ludhiana. The weed growth was less with the other treatments in practice. The physical properties revealed that woven mats had 53.93% water holding capacity than non-woven mulch mat (89.03%). The soil composition analysis showed that the *p*H was reduced to 8.0 from 8.5 with the use of different treatments. The micronutrients of the soil, viz. zinc (Zn), copper




(Cu) and manganese (Mn) increased with the use of these treatments. Two technologies, i.e. finger guards (*Nakhalya*) and digging tool (*Ukeri*)developed by ICAR-CIWA, AICRP Centre, VNMKV, Parbhani were tested and validated. Improved Ring Cutters for vegetable harvesting were upscaled and provided to AICRP centers at Pantnagar, Hyderabad, Palampur, Udaipur and Hisar. A garlic peeling machine and an *amla* de-seeding machine were fabricated and provided to the workers of selected food processing units by ICAR-CIWA, AICRP Centre, VNMKV, Parbhani.

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Basic and Strategic Research

The 'National Agricultural Science Fund' (NASF) supports basic and strategic research in agriculture along with translational research, research in International collaboration, Scientific validation of Farmers' Innovations etc. The main objective of the scheme has been to build capacity for basic, strategic and cutting edge application research in agriculture and address issues which can be solved by intensive basic and strategic research jointly by team of organizations/ institutions. Underlying this objective are the following aims: (i) Foster research and a research culture that will use and advance the frontiers of scientific knowledge to effectively meet the present, anticipated and unanticipated problems of agriculture through various modes and critical investments in research projects; (ii) Build the capability of the National Agricultural Research System through development of wide partnerships in science through projects; (iii) Build a storehouse of advancement of knowledge in science related to agriculture and awareness of the national importance of basic and strategic research in agriculture; (iv) To provide policy support to the decision makers for use of basic and strategic research in agriculture and; (v) Organization of workshop, seminars, conferences, etc. to create awareness, prioritization, scientific popularization and related issues. At present, 89 projects are in operation and 85 of then are multi-institutional in nature. During the reported period, NASF has taken many new initiatives like award of projects on Scientific Utilization through Research Augmentation-Prime Products/ Panchagavya from Indigenous Cows (SUTRA-PIC) and Extramural Research (EMR) besides developing CRISPR Crop Network for targeted improvement of stress tolerance, nutritional quality and yield of crops by using genome editing. A total of 27 new projects under seven strategic areas were approved during the reporting period. In addition, four new projects on SUTRA-PIC programme and extension of 11 projects on Extramural research were also sanctioned.

Salient Achievements

During 2021–22, besides having more than 53 research publications in reputed journals, NASF had three patents and eight technologies. The research highlights of some selected projects have been summarized here.

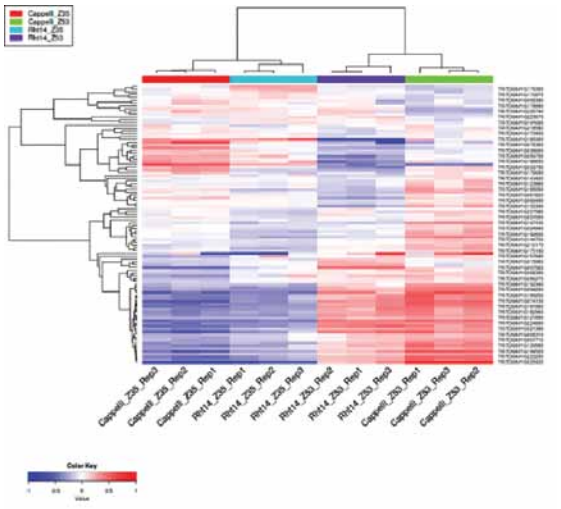
Genome editing for improvement of yield and climate resilience of rice: Genome-editing technology (CRISPR-Cas9) was used to create loss of function mutants of the *Drought and Salt Tolerance* (*DST*) gene, a zinc finger transcription factor, in rice cultivar MTU 1010. Three homozygous mutants were developed with reproductive stage tolerance to salinity stress. These lines were further evaluated for yield under drought stress and non-stress conditions. *DST* gene mutants showed >25% increase in grain yield under normal conditions due to increase in reproductive tillers per plants and grain number per panicle. Under drought stress (-75 KPa), genome edited mutants showed a significantly higher grain yield as compared to MTU 1010.

Identification of superior donors and alleles under thermal stress in rice: Phenotypic variance of 436 rice accessions from the sequenced panel of 3,000 rice genome accessions was assessed at multiple locations across India. One gene belonging to a small molecular weight heat shock protein (sHsp) and two belonging to the heat shock factor (HSF) family had non-synonymous changes, which have the possibility to be developed as markers. Three rice accessions with consistently high spikelet fertility under high temperature, seven accessions with low chalk and eight accessions with cold tolerance were identified. These identified accessions can be used as pre-breeding material for introgressing these traits in elite varieties. Further, 40 QTLs and 10 QTLs, significantly associated with high spikelet fertility and low grain chalkiness in high temperature, respectively, were also identified. A set of 3,201 genes that were differentially expressed by high temperature stress at the booting stage in rice was recognized.

Identification of QTLs for subcomponent traits of WUE in rice: A panel of 150 diverse accessions from the 3K rice genome panel of IRRI was assembled and extensively phenotyped in the Phenomics Facility under well-watered (100% FC) and water limited (60% FC) conditions. The traits showed remarkable consistency across water regimes and seasons indicating a strong genetic control of physiological traits. It was demonstrated that Leaf Mass Area (LMA) was closely related to NAR, and was an important determinant of drought adaption under water-limited conditions. Stomatal traits measurements revealed that higher stomatal frequency combined with small size showed higher WUE. Molecular analysis using the large SNP database available for these genotypes led to the identifications of robust QTL associated with these traits by Genome Wide Association Studies.

Fine mapping and marker-assisted breeding to develop semi-dwarf wheat genotype: The developing peduncle tissues among *Rht14*, *Rht18,* and tall genotypes were tested for transcript analysis. RNA sequencing approach was used to identify novel candidates involved in alternative dwarfism in wheat. About 24 differentially expressed genes (DEG) from *Rht18* and *Rht14* regions were identified at two stages of stem elongation. Three genes mapped within the *Rht18* locus in fine-

mapping studies showed differential expression in stem development stages. *Rht14* and *Rht18* genotypes shared five common DEG, whereas 19 DEG were distinct, suggesting the possibility of an independent dwarfing mechanism for *Rht14* and *Rht18*. *Rht14* and *Rht18* are being transferred to the background of well-adapted, high-yielding bread wheat (HD 2967, HD 3086, HI 1544, HI 1500, C-306), durum wheat (HI 8498) and dicoccum wheat (NP 200) varieties by marker-assisted breeding. It will provide advanced wheat breeding lines with alternative dwarfing genes and better seedling establishment traits suitable for conservation agriculture.



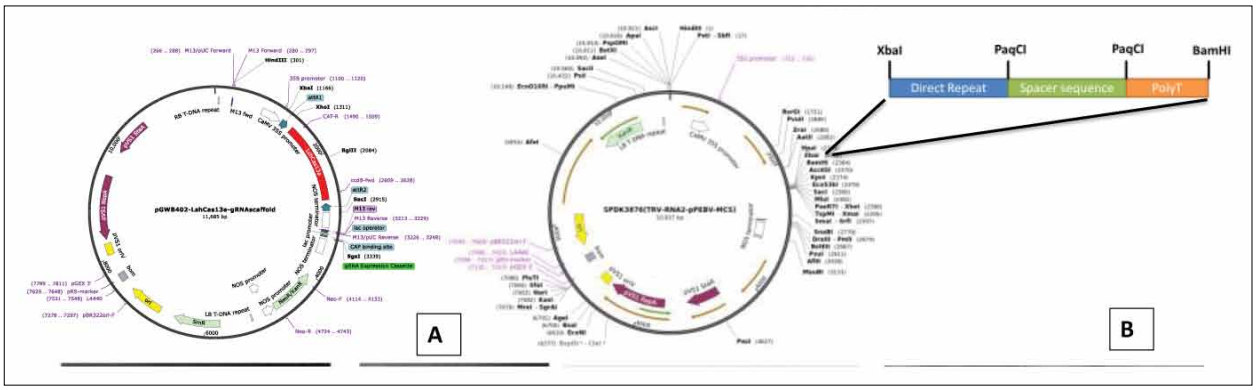
Expression profile of top differentially expressed genes in *Rht14* genotype.

Exploiting alien genetic resources for developing climate resilient wheat: Germplasm comprising 400 accessions including wild relatives and progenitors of wheat phenotyped for heat stress tolerance was genotyped using 35K Axiom SNP chip to identify the novel genes/QTLs. Under late-sown conditions, the major SNPs for SPAD and CFL were found on 2A, 3A; 11 SNPs for GFD on 3A and 2B; and 5 SNPs for TGW on 2B, 3A, 5D, 6B and 7B. Under timely-sown conditions, major SNPs for SPAD and CFL were identified on 2B and 7A; for GFD on 1D and 2A; 24 SNPs for TGW on 1B, 5A and 5B. Using a set of 310 *T. durum*/*Ae. speltoides* BILs phenotyped for heat-stress tolerance and genotyped by sequencing, 50 QTLs were detected on all the chromosomes except 7B. Consistent QTLs were detected for various heat tolerance traits under OE and HE across the years. Under HE, seven QTLs, viz. *QSn.pau-Td-HE-2B*, *QSn.pau-Td-HE-7A*, *QPl.pau-As-HE-3B*, *QGw.pau-Gw-Td-HE-1B*, *QGps.pau-Td-HE-2B*, *QGfd.pau-Td-HE-2A.2* and *QDtm.pau-As-HE-6A* were detected. The QTL for SL QSL.pau-DS-OE-HE-5A on chromosome 5A was detected under both OE and HE. For HTI of the phenotypic traits, six QTLs viz. *QHti-Sn.pau-Td-7A*, *QHti-Sl.pau-As-5A*, *QHti-Pl.pau-As-2A*, *QHti-Gfd.pau-As-1B*, *QHti-Gfd.pau-As-6A* and *QHti-Dtm.pau-As-1B* were mapped that were stable across the years.

Identifying the genomic regions and genes for drought and heat tolerance in groundnut: To identify the genomic regions for drought and heat tolerance in groundnut, eight parents and 500 lines of the MAGIC population, 432 RILs of TMV2 × TMV2-NLM and 250 RILs of JL 24 × 55-437 were subjected for DNA sequencing. The linkage map constructed with 700 SNP markers could identify major main effect QTLs for pod yield with the highest PVE of 10.5%. Nine QTLs with the highest PVE of 18.4% were identified for Shoot Dry Weight (SDW). A few of them were also involved in epistatic interactions, and formed multiple QTL mapping models. Five major QTLs for SDW were stable over both the locations. Candidate genes with SNPs and *AhMITE1* insertion were identified for the major QTL regions. Map was also constructed using 478 SNPs for the RIL population of JL 24 × 55-437. Forty-five major main effect QTLs were identified for 21 traits. Three QTL clusters (Cluster-1-Ah03, Cluster-2-Ah12, and Cluster-3-Ah20) harboured more than half of the major QTLs for target traits, explaining as high as 38.6%, 44.6%, and 49.5% of PVE, respectively. Candidate genes encoding heat shock protein, heat shock transcription factors, and flowering regulation genes were identified at QTL clusters. Population structure analysis identified four subgroups. Seven significant marker-trait associations for five traits were identified in 374 kb (carrying 348 genes) genomic region on chromosome Ah18.

Development of sustainable management tools for fall armyworm in maize: The maize genotypes, viz. CML 44 BBB (3.0), DML 163-1 (3.5), IML 16-248 (4.0) were found promising based on leaf damage rating (1-9) scale for foliar resistance to fall armyworm (FAW) (*Spodoptera frugiperda)* artificial infestation. The expression study of lipoxygenase and BXs pathway genes and correlation analysis of jasmonate and BXs metabolites indicated that induction of toxic BXs accumulation in resistant genotypes depends on JA signalling pathway. Higher content of threonine (Thr) and arginine (Arg) was found in BML 6 (susceptible line) and lower in resistant lines (DMRE 63, CML 71). Five geographical populations of FAW were assessed for molecular diversity using the Tpi marker to resolve the ambiguity in mtCOI-based strain identification. All were identified as corn strains based on nucleotide variations at positions 168, 180, and 183 of the Tpi exon, where a few individuals also had Corn-Rice inter-strain signatures at certain positions. Also, more than 90% of the FAW population in India is corn strain according to sequenced data and NCBI data.

Genome editing for imparting PRSV resistance: In order to impart resistance against Papaya Ring Spot Virus (PRSV), a high throughput papaya transformation and regeneration protocol towards genome editing of the eIF4E gene family was established and CRISPR/Cas9 mediated editing of eIF4E gene family was undertaken. For CRISPR-Cas13A mediated editing of PRSV genome, two different constructs were



CRISPR-Cas13a mediated editing of PRSV genome by transient delivery systems and evaluation of their efficacy against PRSV infection in squash plant. (A) Binary vector harbouring LshCas13a and gRNA expression cassette; (B) Modified TRV RNA2 vector expressing LshCas13a-specific gRNA expression cassette under PEBV promoter

developed. The first construct was developed in a binary vector where LshCas13a and gRNA expression cassette were introduced. The second construct was developed in a TRV RNA2 vector which could express a specific gRNA expression cassette under PEBV promoter. For the gRNAs, spacer sequences were designed from Vpg and other genes like CP and HC-Pro. The binary construct was agro infiltrated into leaf of squash plant (a host of PRSV) followed by rub inoculation of PRSV. Treated plants did not show any symptoms while only PRSV inoculated plant showed severe symptom of the disease been undertaken.

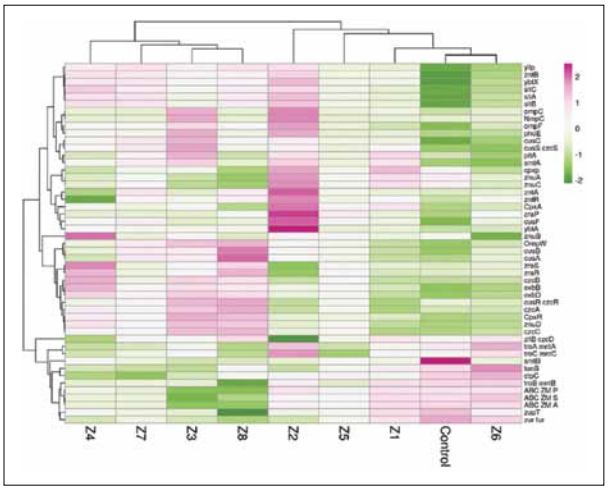
Targeted editing of the potato genome to develop variety specific True Potato Seed: Out of 32 putative transformants *MiMe* generated lines, 16 lines showed mutation in the region other than target area of *StOSD* gene, 7 lines showed mutation in *StREC8* gene and only one line showed modification for *StSP011* gene, however, it is present within the gene. Overall, the average editing efficiency (number of edited plants/number of transgenic plants) for *MiMe* genes was 50% for *StOSD* gene, 21.8% for *StREC8* gene and 3% for *StSP011* gene. Similarly, 46 CENH3 edited/mutated lines were selected, in which, 35% mutation (insertions or deletions) were analysed at the target sites. Fourteen independent events for CENH3 mutation were selected and crossed with control Kufri Jyoti plants for evaluation of haploid induction efficiency. The TPS were germinated and screened for haploid induction efficiency using FACS and Sanger sequencing. Five CENH3 edited lines, viz. CENH3 1a(4), CENH3 1a(32), CENH3 2a(20), CENH3 2a(19) and CENH3 1a(11) showed the 11%, 15.7%, 10.9%, 10.8% and 15.6% efficiency of diploid induction with tetraploid wild type Kufri Jyoti.

CENH3 mutant lines were used as a female parent to cross with wild type K. Jyoti plants (a); CENH3 mutant lines were used as a male parent to cross with wild type K. Jyoti plants (b); TPS collected from berries where CENH3 mutant lines were used as female parent or male parent (c); Seedling obtained from TPS (d) and (e), which were screened for haploid induction efficiency; using FACS and Sanger sequencing (f)

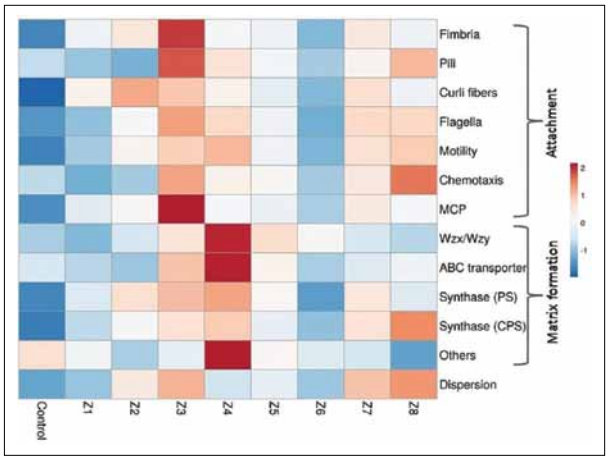
Population diversity of banana streak viruses (BSV) in diploid seedy banana of North East India: A total of 285 banana mats/genotypes collected from different groves of North Eastern (NE) states (Manipur, Mizoram, Nagaland, Tripura, Arunachal Pradesh, Sikkim and Assam) were characterized for endogenous banana streak viruses (eBSV), which indicated the prevalence of distinct/novel alleles having similarity to endogenous banana streak OL virus (eBSOLV), banana streak IM virus (eBSIMV), banana streak GF virus (eBSGFV) and *Musa balbisiana* PKW type activable alleles, the allelic positions of which make them activable. Activable eBSV being harboured by banana genotypes of NE India are potential blueprints of episomal BSV diversity. Full length cloning of 14 episomal BSV isolates (sampled from Manipur, Nagaland, Sikkim, Tripura, Arunachal Pradesh and Assam) and sequencing was done. Full genome sequence of a new badnavirus banana streak MH virus (BSMHV) associated with streak disease of banana cultivar *MeteiHei* (ABB) grown in Manipur was achieved. Banana streak MY virus (BSMYV) was the most prevalent episomal DNA virus associated with streak disease of banana genotypes (AAA, AAB, ABB) in NE India.

Metagenomic insights into regulation of homeostasis, co selection and horizontal gene transfer of metal and antibiotic resistome under Zn selection

pressure in soils polluted with nano zinc oxide: Soil Zn application as nano-ZnO (nZnO) or bulk ZnO (bZnO) induced marked shifts in bacterial community structure, with dominance of *Sphingomonas* and *Nitrospira* under nZnO exposed soils, while *Bryobacter*, *RB41*, *Candidatus Solibacter* and *Flavisolibacter* dominated under bZnO exposed soils. Genes related to major Zn influx systems viz., *znuABC, troABC, ABC.ZM.SPA, sitABC, pitA, zupT, ZntB* and *ybtX* were augmented under nZnO than bZnO. Co-occurrence network analysis revealed poor correlation of soil bacterial communities with major efflux systems such as *czcCBA*, *cusCFBA*, *zntA*, *czcD*/*zitB* and *yiiP* under nZnO, indicating enhanced influx and subdued efflux of Zn under nZnO. Co-occurrence network analysis also revealed significant positive correlations between abundances of ZRGs (Zn resistance genes), ARGs (antibiotic resistance genes) and mobile genetic elements (MGEs), indicating an enhanced probability for co-selection and horizontal gene transfer of resistome in nZnO polluted soils. Soil available Zn was the major driver for co-selection of ZRGs and ARGs as well as HGT, and co-transfer of all three genetic determinants could be a high-risk scenario for dissemination of antibiotic resistance under nZnO. Both nZnO and bZnO facilitated profusion of biofilm genes (BGs) among soil bacterial communities especially at higher Zn levels (500 and 1000 mg/kg Zn). In general, nZnO favored enhancement of genes involved in exopolysaccharide biosynthesis and attachment, while bZnO favoured genes related to capsule formation, chemotaxis and biofilm dispersion.



Heat map depicting dominant Zn homeostatic genes and their regulators in the soil bacterial metagenome exposed to different levels of Zn as nano ZnO and bulk ZnO [Control, Z1-50; Z2- 200; Z3-500; Z4-1000 mg Zn (II)/kg as nZnO; Z5-50, Z6-200, Z7-500, Z8-1000 mg Zn/kg as bZnO].



Heat map depicting abundance of biofilm genes related to attachment, matrix formation and bulk ZnO [Control, Z1- 50; Z2- 200; Z3-500; Z4-1000 mg Zn/kg as nZnO; Z5-50, Z6-200, Z7-500, Z8-1000 mg Zn/kg as bZnO].

Development of biosensors for detection of fish pathogenic bacteria and hazardous metalloids in selected water bodies: Several nanoparticles including gold and silver nanoparticles were synthesized to check their suitability to enhance the signalling efficiency of the developed Molecular Recognition Element (MRE). A sensor was developed for the efficient detection of Cr (VI) in water with a linearity range 100 ppb to 1 ppm. The UV-Vis absorbance intensities were gradually increased with increasing concentration of Cr (VI). The sensor is able to detect Cr (VI) up to 100 ppb which is the permissible limit notified by US EPA. It does not show any cross-reactivity when checked with other heavy metals like Cr (III), Pb, As, Hg, Ba, Cd and ions (SO_4^{2-}, CO_3^{2-}, HCO_3^-). The sensor has been incorporated into a hand-held prototype device. Another aptamer-based biosensor was developed for the detection of fish pathogenic bacteria *Aeromonas veronii*. The sensor is able to specifically detect *Aeromonas veronii* and shows

Enhancing decomposition rate and quality of bio-waste through microbial consortia for improving soil health

The potential lignoceullulotytic microbes (including bacteria, fungi, actinomycetes) were identified and the 'Ekcel decomposer' consortia was prepared; and the drum type composting unit and shredder machine viz. 'Ekcel Composter' and 'Ekcel Shreder' were also fabricated, which help in accelerating the decomposition of different bio-waste (viz. farm waste, horticultural waste, kitchen waste and vegetable waste). By using these technologies, quality compost can be readily prepared for field application within 25-45 days depending on substrate, i.e bio-wastes. The field evaluation studies reveal that enriched compost significantly enhanced the crop productivity over recommended dose of fertilizer. The 'Ekcel decomposer capsule' was also developed and released. The capsules were used for *in-situ and off-situ* decomposition of rice-wheat residue in farmer's field of Bhopal.

no cross-reactivity with other bacteria when tested against *A. hydrophila* (AH), *Pseudomonas aeruginosa* (PA) and *Klebsiella pneumoniae* (KP). The sensor is able to detect the bacterial cell up to a concentration of 10^6 CFU/mL.

Development of biological filter for safe waste water irrigation exploiting microbial bioremediation trait: The four bio filters were designed and prototypes were developed. The bio filters using different packing materials performed differently, where high surface area plastic media (FRP) showed highest COD removal and gravel performed well for sulphate and chromium removal during batch study. During continuous operational mode, treatment efficiency of graphite bio filter was highest for COD and sulphate through out study. However, at the given loading rate, all the reactors performed nearly equally for heavy metals, except for Manganese (Mn). The order of Mn removal efficiency was Gravel> Graphite> FRP. The characterization of biofilter packing material before and after treatment was done. Comparison of plots showed shift in XRD peaks and also few new formed peaks suggesting the adsorption of heavy metals and its precipitates. FESEM revealed the unevenly distributed presence of heavy metals over the surface of packing material.

Production of multiple copies of elite buffalo bulls using animal cloning technology

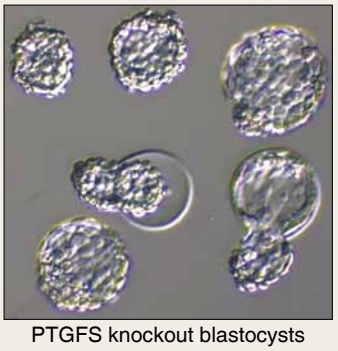
Thirteen clones of 6 superior breeding male and one elite buffalo female were produced. Out of that, seven copies were produced from a single superior breeding bull M29 and three copies were from first ranked progeny tested bull Mu-4354. A calf of an earlier cloned bull Hisar-Gaurav was also successfully re-cloned. The cloning efficiency was improved from 1% to 6-8% using different combination of epigenetic modifier to increase cloned embryo production and efficient management of recipient and born calves. Through *in vitro* fertilization test and *in vivo* artificial insemination, fertility of the cloned bulls (n=4) was comparable to non-cloned breeding bulls. Further, frozen semen of cloned bulls was used for artificial insemination and it produced more than 60 parentage verified calves with normal health at both centers ICAR-CIRB, ICAR- NDRI farm, other dairy farms and farmers' farm, which indicates fertility and breeding value of cloned bull.

Progenies born through artificial insemination using semen of cloned bull

Targeted immobilization of Y-bearing spermatozoa and modulation of oviduct milieu for skewing sex ratio towards female offspring in dairy cattle: The sex specificity of the four identified potential proteins was assessed using FISH and Western Blotting techniques and found that all the four proteins were specific to Y-Chromosome bearing spermatozoa. A targeted immobilization method was developed, using iron nano particles conjugated with the developed antibodies (polyclonal), to immobilize the Y-Chromosome bearing spermatozoa. Cattle embryos were produced through *in vitro* fertilization technique using the semen enriched with X-Chromosome bearing spermatozoa (using the developed Y-chromosome bearing sperm immobilizing method) and sex of the embryos was assessed. The developed immobilization technique resulted in production of 72-76% of female embryos. Similarly, a model for assessment of sperm-oviduct binding was developed for cattle and found

CRISPR/CAS9 guided functional analysis of genes regulating early embryonic survival in buffalo

For *in vitro* over-expression studies, PTGES and PTGFS coding sequences (462 bp PTGES and 972 bp PTGFS) were cloned in CT-GFP Fusion vector followed by sequence confirmation of the clones. Buffalo endometrial epithelial cells were transfected with PTGES and PTGFS constructs followed by screening of transfected cells by GFP fluorescence. There was slight up regulation of PTGES and PTGFS mRNAs in transfected cells as compared to control. Cloning of two sgRNAs against COX-2 gene into CRISPR/Cas9 expression vector (PX459) was confirmed by sequencing. The resultant CRISPR/Cas9-sgRNA constructs were subsequently used for transfection into *in vitro* cultured buffalo endometrial and luteal cells. RT-PCR data revealed that mRNA expression profile of COX-2 gene following CRISPR/Cas9 mediated editing using two gRNAs exhibited significant decline in PGF_{2x} production and COX-2 gene expression. An inexpensive, yet efficient, methodology for microinjection of CRISPR/Cas9 constructs into mouse zygotes was developed. This methodology was applied for microinjection of PTGFS Cas9-gRNA construct into mouse embryos. The COX-2 and PTGFS Cas9-gRNA construct was loaded in the microinjection needle and each zygote was injected with 3-5 pL of construct, according to the standardized hypothetical divisions of microinjection needle. The microinjected zygotes were *in vitro* cultured up to the blastocyst stage. The knockout efficiency was determined using the T7 endonuclease assay. The T7 assay revealed the effective knockout of COX-2 and PTGFS gene in blastocysts. Simultaneously, the embryos were transferred to foster mice. No pregnancy has been achieved till date.

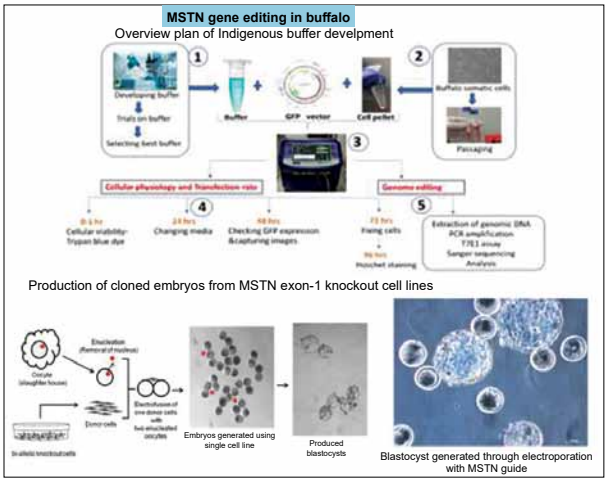


PTGFS knockout blastocysts

that incorporation of calcium at 1 mM concentration in the media resulted in 15 times more X-bearing sperm binding to oviduct, and incorporation of magnesium at 3 mM concentration resulted in 33 times more Y-bearing sperm binding to oviduct. Collectively, it is inferred that the sex ratio of the embryos was skewed towards females to 3.16:1 (for every three females one male) using the developed targeted immobilization technique. This means if this techniqu is used, we shall be able to get male to female ratio 25:75.

Production of double muscled-mass farm animals using CRISPR: Two approaches; a) production of MSTN-edited embryos using SCNT, b) delivery of MSTN ribonucleo-protein complexes in single-stage zygote using electroporation were attempted for the production of embryos. Knockout of cell lines (mono-allelic and bi-allelic type) was established in buffalo and sheep, and subsequently, these cell lines were used to produce knockout-edited cloned embryos. The embryo production rates (30-35%) were similar to non-edited control cells. The transfection and handmade cloning protocols were optimized in goats. In addition to these, the indigenous transfection buffer was developed and tested in buffalo and goats. Developed buffer has 20-25% genome editing efficiency, and transfected cells were able to generate single-cell colonies. The developed buffer can be efficiently used to deliver CRISPR components/ transfection materials into any mammalian somatic cells.

Exploiting encapsulated nanoparticle conjugated phytochemicals to combat antimicrobial resistance in poultry: The phytochemical conjugated silver nanoparticles (AgNPs) were encapsulated to achieve



targeted delivery using chitosan-alginate polymers by ionic gelation method. The encapsulation efficiencies (%) of chitosan/alginate encapsulated Ag- conjugated thymol, cinnamaldehyde and eugenol were 80.15±2.23, 71.05±1.73 and 85.20±2.38, respectively. The dialysis method revealed a Fickian diffusion pattern for the release of conjugated molecules; for encapsulated Ag-cinnamaldehyde (EAgC), a maximum release of 85% was observed at pH 8.50 after 6 h, whereas for encapsulated Ag- thymol (EAgT), the maximum release was 95% at pH 7.40 after 7 h. The HPLC-mediated release kinetic data revealed a maximum release of 80% for EAgC at pH 8.0 and 87% for EAgT at pH 7.40, both at 6 h. *In vitro* antimicrobial activity of the encapsulated compounds (EAgC and EAgT) exhibited a 2-fold increase when compared to the conjugated compounds (AgC and AgT). Besides, EAgC and EAgT were variably stable, when exposed to various physicochemical conditions (high-end temperatures, protease enzymes, cationic salts, and pH). All the tested encapsulated leads appeared to be safe (secondary cell line- based MTT assay and commensal gut lactobacilli). Later, the *in vitro* time-kill kinetic assay of encapsulated leads revealed a complete elimination of MDR-EAEC (extracellular) and MDR- NTS (in HEp-2 cell lines) strains by 120 min and 12 h, respectively. *In vivo* antimicrobial activity in *G. mellonella* larvae, LD_{50} dose of 1×10^6 CFU/larvae was determined for MDR-EAEC strains and MDR-NTS strains by probit regression model. Larval studies exhibited increased survival rates, declined bacterial counts, and LDH activity which concurred with the histopathological findings demonstrating the potential antibacterial effect of the identified leads. An LD_{50} dose of 1×10^6 CFU/ml and 1×10^8 CFU/ml was determined in Swiss albino mice, by MDR-EAEC strains and MDR-NTS strains, respectively. The bacterial counts (EAEC and NTS) were reduced significantly among treatment groups. Moreover, complete elimination of MDR-EAEC strains was observed by 5 days post treatment [p.t.] and was found to

'Can-CoV-2 ELISA Kit'- A recombinant protein-based indirect ELISA kit for detection of antibodies against SARS-CoV-2 in canines

A recombinant nucleocapsid protein (NP) based indirect enzyme-linked immunosorbent assay (iELISA) kit was developed for detection of antibodies against SARS-CoV-2 in canines. A codon-optimized NP was expressed in *E. coli* and 46 kDa recombinant protein was purified and characterized. The rNP showed reactivity with the antibody against SARS-CoV-2 by western blotting. The rNP protein also showed reactivity in ELISA for detection of antibodies against SARS-CoV-2. The developed assay was tested for the detection of antibodies in serum samples collected from canines from different clinical setups and tested on serum samples from the pre-covid period. While none of the 30 pre-covid samples tested positive for the SARS-CoV-2 antibodies, the 1,519 serum samples tested from canines collected in 2021 showed a positivity of 42.53% at the RPP value of 25%. The assay has also been validated with the gold test i.e. serum neutralization assay and has been found to be 95.66% sensitive and 93% specific. The kit was formally released by the Hon'ble Minister of Agriculture on 9th June 2022.

Can-CoV-2 ELISA Kit

be at par with the antibiotic control (Meropenem). With regard to MDR-NTS infected and treated groups, highly significant reduction in MDR-NTS strains was observed when treated with encapsulated compounds after 6 days p.t. when compared with infection control.

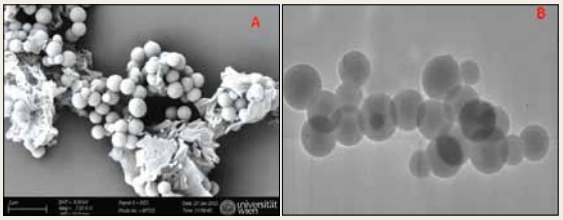
Effect of dietary selenium levels on the performance of goats exposed to endotoxin-induced biotic stress: Evaluation of selenium in the diet of male growing goats under endotoxin-induced stress conditions indicated that crude protein digestibility tended to be high in higher selenium-fed animals, however, no effects on growth, nutrient intake, and digestibility were reported. Absorption and retention of Se improved in 585 and 885 ppb Se-fed goats under normal as well as endotoxin stress conditions. Selenium requirement increased under biotic stress conditions and higher dietary selenium up to 885 ppb ameliorates the adverse effect of endotoxin and improves the metabolism of Se, serum mineral levels, haemoatobiochemical and antioxidant status, hepatic health, select hormone levels, and attenuates proinflammatory cytokines.

Dendritic cell platforms for *in vitro* and *in vivo* studies of antigen processing and presentation in cattle for combined vaccine antigens using FMD virus and *Pasteurella multocida* as model: Purified 146S antigen of FMDV was characterized by double antibody sandwich ELISA and the concentration estimated by spectrophotometry was 82.5 µg/ml for serotype A, 423.3 µg/ml for O and 190.5 µg/ml for Asia 1. Further bacterial ghosts of *P. multocida* were produced using chemical methods and characterized by electron microscopy (SEM/TEM) and SDS-PAGE. The nano emulsion and PLGA (50:50) nanoparticles were produced and characterized by dynamic light scattering, zeta potential and SEM imaging. Size and potential were <500 nm and -12.5 mV for nano emulsion and <500 nm and -19.9 mV for PLGA nanoparticles, respectively. In order to express cytokines in the laboratory, IL4 and GM-CSF genes were cloned and expressed in human embryonic kidney 293 cell lines. Monocyte derived dendritic cells (MoDCs) generated from bovine PBMCs were stimulated with different combinations of FMD antigens, bacterial ghost, OMVs, nano-emulsion and SLNPs, and subjected to flow cytometry analysis for CD40, CD80, CD86 and MHCII (DC markers).

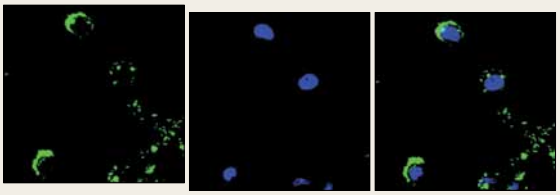
Captive breeding of hilsa, *Tenualosa ilisha:* Captive brood stocks were developed at different environment in three locations with fresh water system at Rahara, intermediate water system at Kolaghat and brackish water system at Kakdwip. After 410 days, fish attained average body weight/length of 443±45.29 g/35.46±1.16 cm at Kakdwip. Formulated brood stock feed (CP- 39% and fat 15%) was offered @ 5-3%. Pond was fertilized weekly, alternate with Plankton^{Plus} (30 kg/ha) and mustard oil cake (60 kg/ha) to maintain the plankton population. Comparative gonadal maturation of captive and wild brood stock revealed that females collected from both captive and river were in similar stage of reproductive maturity with GSI 13.68±0.04 in riverine and 13.05±0.14 in captive condition, while the captive male (av. body weight 122.33±3.38 g) showed advanced maturation (GSI 2.24±0.025) compared to wild male (238.67±4.67 g) with maturing phase (GSI 0.768± 0.002). Around 80% of the captive brood fish were in different stages of maturity. An automated anaesthetic device was developed for safe handling and performing procedures

Synthesis and characterization of mesoporous silica nanoparticles (MSN) as vaccine delivery vehicle

To exploit the adjuvant potential of mesoporous silica nanoparticles (MSN) to thermo stabilize the PPR vaccine virus (PPRV), four types of MSN were synthesized and characterized. Scanning electron microscopy (SEM) imaging of these nanoparticles on a model substrate demonstrated random particle assembly forming a dense scaffold with inter-particle spaces. The nanoparticles were FITC labelled and analysed by fluorescent microscopy and flow cytometry. Confocal microscopy studies demonstrated the uptake of FITC-labelled particles in Vero cells. Different concentrations of nanoparticles were tested for *in vitro* cytotoxicity in Vero cells. The ability of MSN particles for recruiting host cells was studied in laboratory animals. MSNs were evaluated for binding of PPRV and release kinetics was studied. *In vitro* release of PPRV from MSN was confirmed in Vero cells by visualization of cytopathic effects (CPE) and immunofluorescence assay using PPRV-specific antibodies. Immunization with antigen-loaded MSN particles demonstrated the formation of the antigen-MSN depot with inter-particle spaces for recruitment of antigen-presenting cells leading to enhanced immune responses in mice model. The experiments demonstrated that sera from mice and rabbits immunized with MSN-encapsulated PPRV were able to generate neutralizing antibodies and generated comparatively higher antibody responses in comparison to animals immunized with naked PPRV.



Characterization of mesoporous silica nanoparticles (MSN). (A) SEM image of hollow mesoporous silica nanoparticles (HMSN), (B) TEM image of HMSN

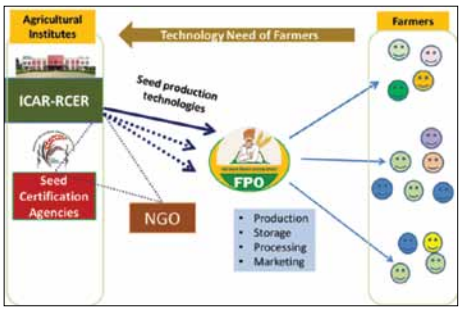


Visualization of uptake of FITC-labelled MSN particles in Vero cells (40× magnification).
(A) FITC labelled HMSN, (B) DAPI stained nuclei, (C) Merged image representing the localization of MSN in the cytoplasm of Vero cells

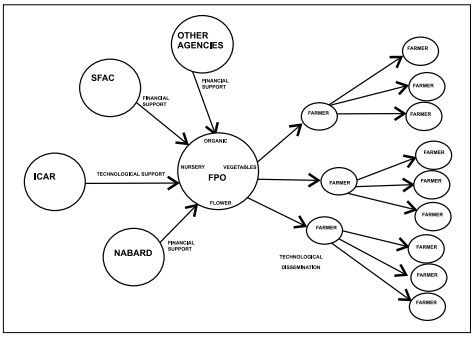
related to reproductive interventions under stress condition and tested on wild and pond-reared hilsa. It can deliver optimum amount of anaesthetic solution with desired flow over the gills through buccal cavity. Among various drugs tested, Tricaine methanesulfonate (MS-222) and 2-Phenoxyethanol (2-PE) were found equi-potent; the time required for complete anaesthesia and recovery was lower. However, based on alterations in the stress enzymes and hormones in response, the MS-222 was found best suited for hilsa.

Understanding molecular basis of host-pathogen-environment interaction of Tilapia Lake Virus disease: Two qRT-PCR assays targeting TiLV genome segments 1 and 10 were standardised and employed to determine the viral load in liver, brain and spleen tissues of experimentally-infected tilapia. The assays detected higher viral load in liver than that determined in spleen and brain at all-time points post-infection. The study revealed an increasing trend in the viral load in the early stages of infection and a steady decline in the later stages. Based on the consistently higher viral load observed in the liver, it is proposed that the liver tissue can be the best target tissue for the reliable detection of TiLV. Further, the newly designed real-time PCR assay targeting TiLV genome segment 10 showed high sensitivity and can be used for the reliable detection of the virus.

Development and validation of need based technology delivery model through farmers' producer organization for eastern region of India: The four models of technology delivery through FPO were developed for seed production, vegetable production, organic farming and natural resource management in ICAR-RCER, Patna; ICAR-IIVR, Varanasi; ICAR-RCER, FSRCHPR, Ranchi and UBKV, Cooch Behar respectively. The communication pattern of FPO and Non-FPO farmers was assessed through Social Network Analysis. The cohesiveness, sparsity and degree of influence of FPO were better than non-FPO farmers. It was found one of the important tools for Leadership identification on the basis of network plot.

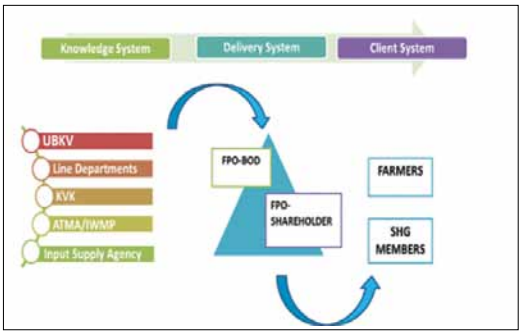


Model 1: FPO based quality seed production and marketing model



Model 2: FPO based safe food production technology delivery model

Model 3: FPO based Vegetable produce marketing technology delivery model



Model 4: FPO based Natural Resource farming technology delivery model

Development and validation of Smart Aquaculture Model (SAM) for sustainable shrimp aquaculture: An android mobile application-CIBA Shrimp Krishi App was developed and launched for handholding the shrimp farmers to make real-time based informed decisions at farm level. The app is free and available in four languages viz., English, Hindi, Tamil and Telugu. Using this interactive mobile application, the farmer can input his farm data on day-to-day farming operations/ observations from stocking to harvest. Based on the inputs provided and inbuilt decision-making system, the app will display pond-wise status on shrimp survival, biomass, feed conversion ratio, pond water quality, and the expenditure incurred. The expert systems inbuilt in to the app alert the end-user farmer with technical advisories whenever any deviations are noted in day-to-day parameters of water quality, feeding and shrimp health. The app can store the entire crop data in it, and the farmer can retrieve the data for their own long-term decision-making purposes or share it with their resource person for technical advice. The app has a post-your query option through that the end-user can send his queries in text or image format which are answered in two working days. Moreover, it paves the way for accessing real-time bulk data from the remotely located shrimp farms to monitor and extend customized technical advisories. The app is also available in windows platform to enhance its adoptability and both versions are interchangeable. ❑

16.

Information, Communication and Publicity Services

ICT initiatives

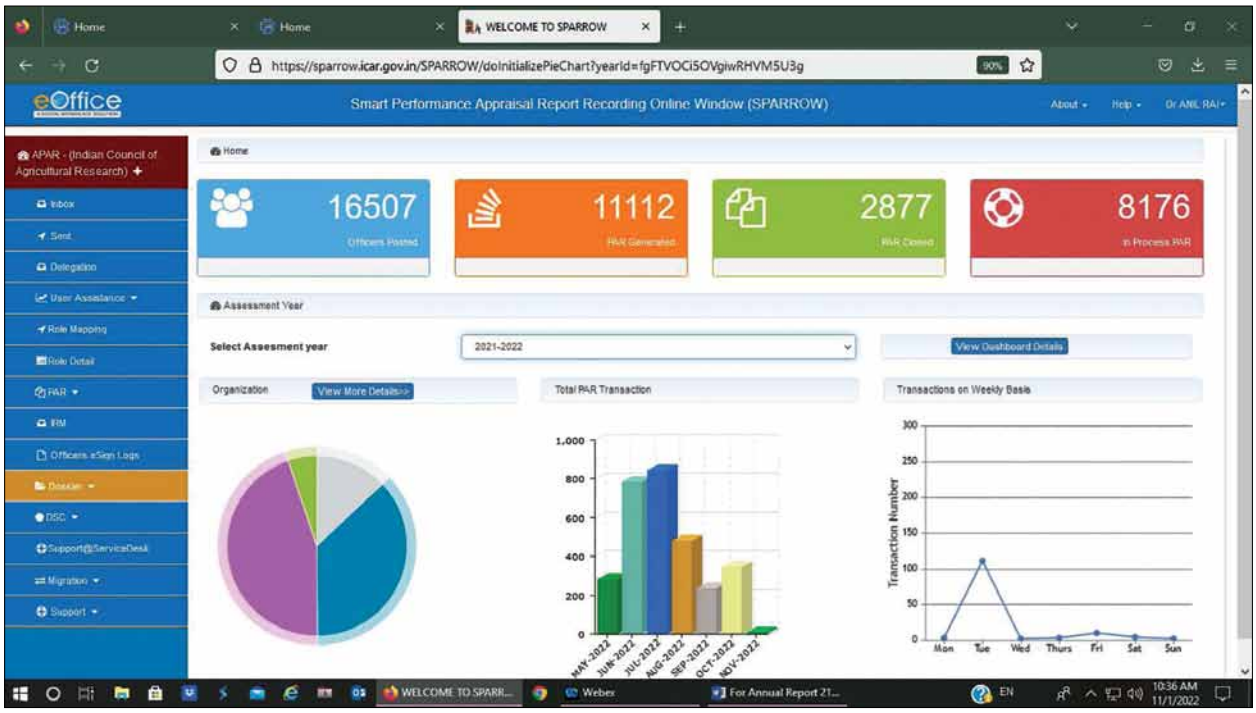
Smart Performance Appraisal Report Recording Window (SPARROW): The SPARROW is an online system based on the comprehensive performance appraisal dossier that is maintained for each employee of the Council by the Government. The aim of this system is to facilitate the electronic filling of PAR by officers to fill their Annual Performance Appraisal Report (APAR) from anywhere anytime as per their convenience. Similar convenience is available to the officers at different stages in the workflow hierarchy of filling, submission, reporting and reviewing process.

PAR filling process starts at the beginning of the financial year. The Custodian of the respective Ministry/department sends the blank PAR forms to the individual officer. The officer fills the PAR for further submission to his/her Reporting Officer. The PAR moves from Reporting officer to Reviewing officer and to Accepting Authority mandatorily marking CR Section.

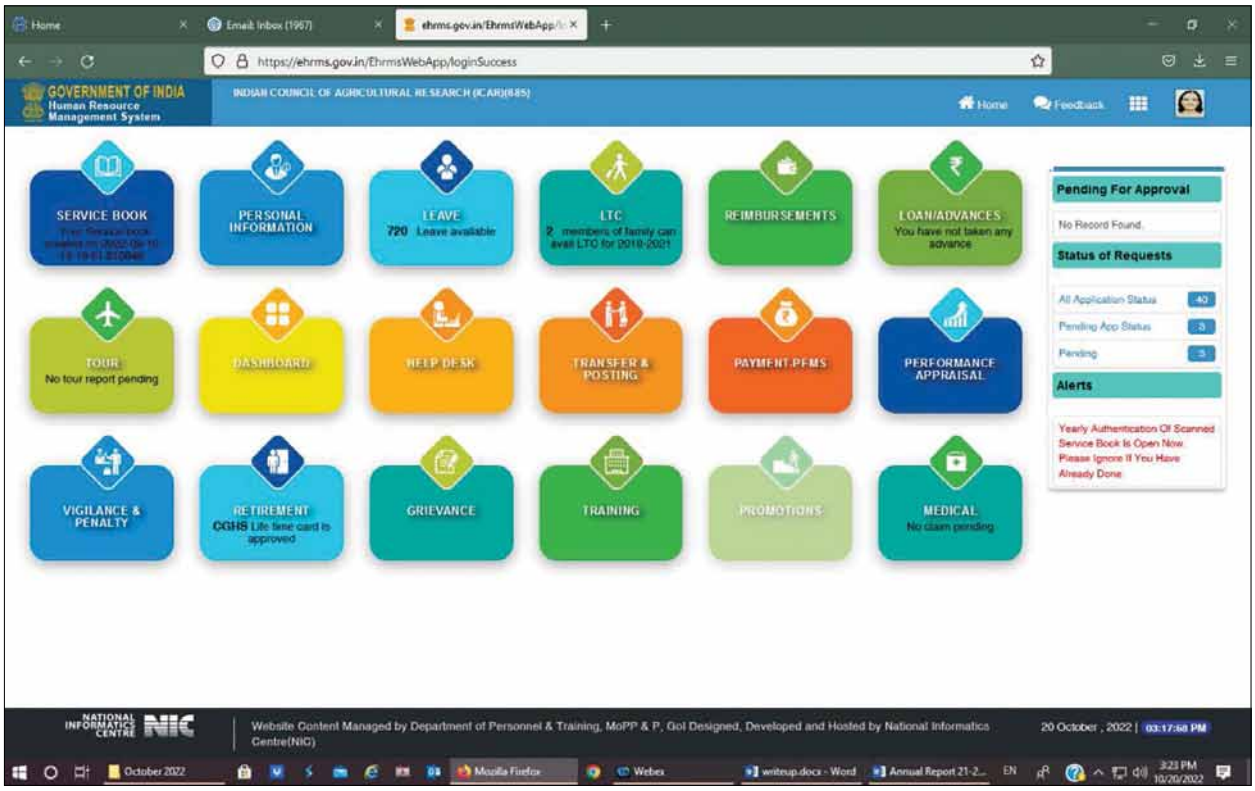
In ICAR, SPARROW is implemented for Administrative, Technical and Supporting Cadres and 11,112 PARs generated for the year 2021-22. The online training to Nodal Officer/Master Trainer/ Custodian/Admin was given to officials of ICAR Headquarters and respective ICAR Institutes.

Electronic Human Resource Management System (eHRMS): eHRMS is a work flow based online human resource management solution for Government Department for proper monitoring, posting, leave, LTC, reimbursement, advances related administrative activities. It consists of all processes/information impacting service book from joining to retirement of an employee. This system can be accessed online (https://ehrms.gov.in) by using NIC email credentials.

The Leave module of e-HRMS has been made operational for the use of all staff members of ICAR Headquarters in 2021. Scanning and digitalization of service record of ICAR Hq have been completed and eHRMS modules related to LTC, reimbursement of Newspaper Bills, Telephone Bills, Mediclaim and Children Education Claim have been made go-live from November 15, 2022. Onboarding of ICAR Institutes on eHRMS is under process.



Dashboard of ICAR-SPARROW



eHRMS modules shown at user dashboard

ICAR eOffice: eOffice is a software that can be deployed/hosted in any data centre or in any cloud identified by the organization. To make paperless/ environment friendly office, e-office software developed by NIC has been implemented in ICAR Headquarters along with 113 ICAR Institutes and their Regional Stations/Sub-Stations. ICAR eOffice is hosted at ICAR Data Centre. Currently eOffice is running in the Council and its institutes successfully. Implementation of eOffice in ICAR has completely transformed the working of office in ICAR and has empowered officers to work during difficult time of COVID.

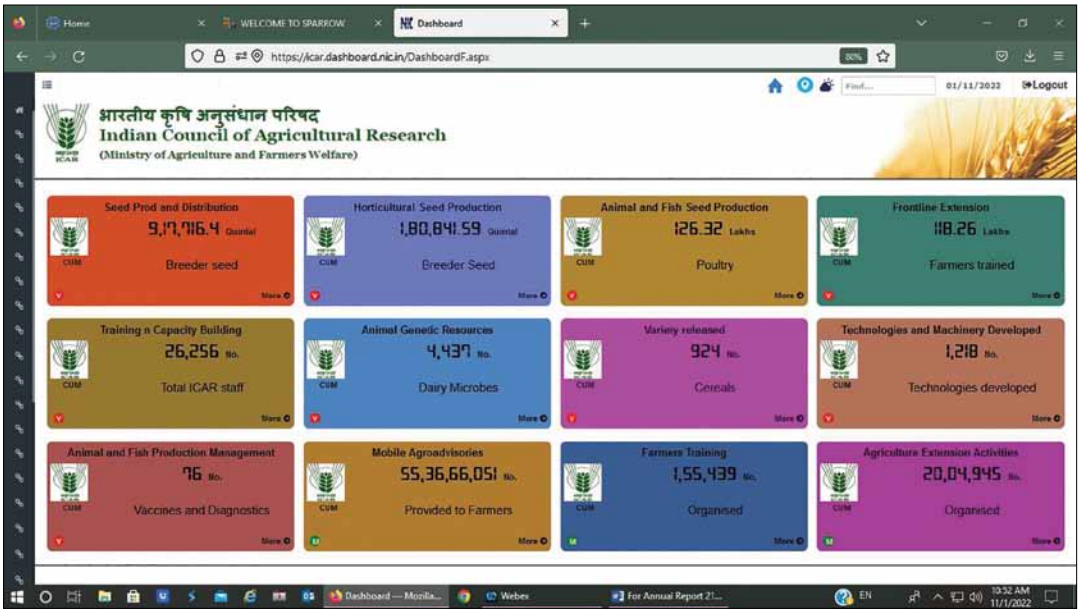
ICAR DARPAN Dashboard (http://icar.dashboard.nic.in): ICAR DARPAN Dashboard is customized using DARPAN portal developed by NIC to transform complex government data into compelling visuals. It is a tool, needed to deliver real-time, dynamic project monitoring without coding or programming through web services. It enhances the analytical capabilities through data collection by consolidating multiple data sources into one centralized, easy-to-access platform. It immediately identifies trends and quickly drilldowns into data to gain enhanced perspectives of the district level projects/schemes. All ICAR Schemes/Projects are classified into 12 projects which consist of 25 Key Performance Indicators (KPIs).

Out of these 12 projects, Mobile Agro-advisories, Farmer's Training and Extension Activities are dynamic and district level data has been pushed to this system from KVK Portal using API.

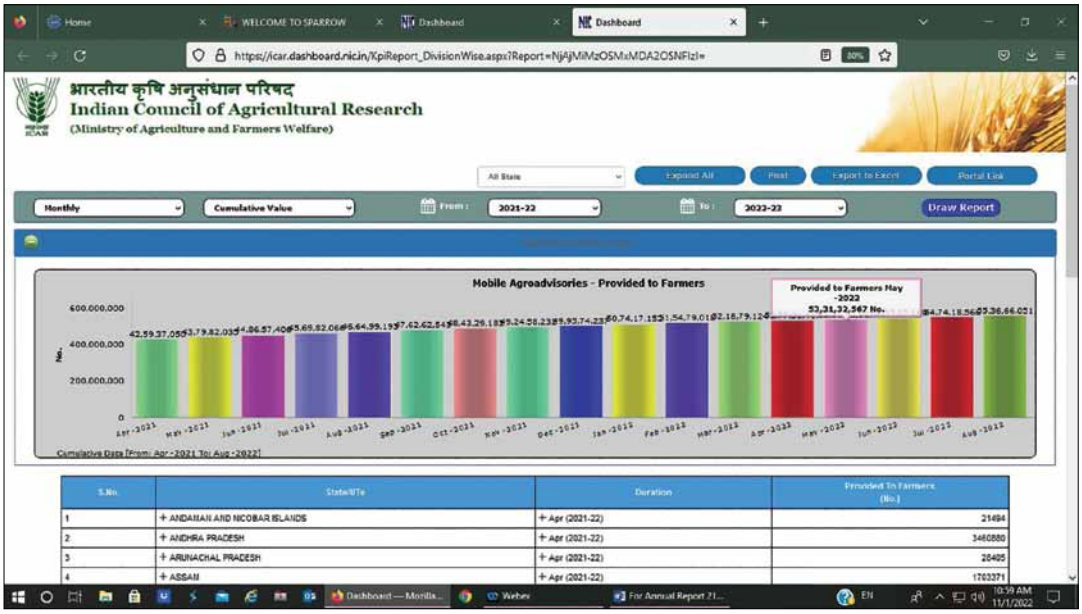
Land Records Management System (LRMS): ICAR-Land Records Management System (LRMS) is an integrated system which provides land record information of all institutions along with their Regional Stations. LRMS keeps the online record as total land area, land utilization details (Farm area, Research Area, area under building, area under sports ground/park/green area, forest area, vacant land), Ownership description as per revenue record, Date of Possession as per revenue record, Date Acquisition, Free hold land/leased hold, Lease Period, Date Start for lease, Date of renewal of Lease etc. User of the system can login to LRMS at http://lrms.icar.gov.in through his/her ICAR email Id and password. LDAP authentication has also been used for login using ICAR emails of heads of administration, director (works), deputy director generals, system administrator and directors of ICAR institutions. Subject Matter Division (SMD) and institute-wise land utilization and land ownership report and SMD-wise consolidated land record report has also been implemented in LRMS. The notification about land record, monitoring and master plan was also implemented in Head of administration and director's (works) dashboard.

The information obtained from ICAR-LRMS can be readily used for deciding the future policies for land management by council. In total 209 institutes/ KVKs/ Regional stations have already filled their land record data into the system. The details of number of institutes, KVKs and regional stations are given as: ICAR Institutes : 76, Regional station : 89, KVKs : 26, Other institute locations:16. Filling of land record from rest of the institutes is in progress at present.

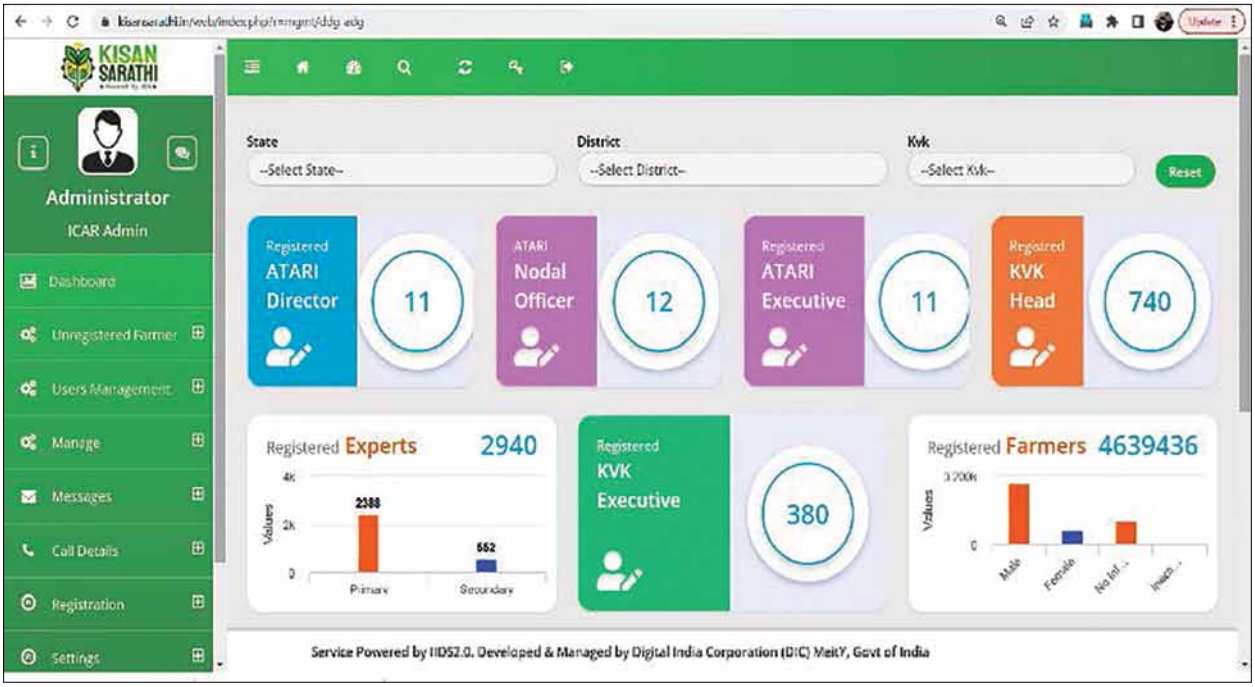
KISAN SARATHI - System of Agri - information Resources Auto - transmission and Technology Hub Interface: To support this emerging need of multi ways and multilingual communication among various agricultural stakeholders, "Kisan Sarathi" an Information Communication and Technology (ICT) based interface solution has been launched on 93rd Foundation Day of Indian Council Agricultural Research jointly by the Hon'ble ministers Shri Narendra Singh Tomar, Agriculture and Farmers' Welfare and Shri Ashwini Vaishnaw, Information and Communication Technology, Government of India in the presence of Shri Parshottam Rupala, Minister of Fishries, Animal Husbandry and Dairying, Shri Kailash Choudhary, Minister of State for Agriculture and Farmers Welfare and Smt Shobha Karandlaje, Minister of State for Agriculture and Farmers Welfare. The ultimate goal of this project is to implement an intelligent online platform for



ICAR DARPAN Dashboard



Graphical view of Mobile Agro-advisories provided to farmers



Development of In-house Drone

Multirotor quadcopter design for agriculture health monitoring and surveying has been developed as part of project. It includes features like, real-time telemetry demonstration at any specified location, full HD live video transmission with dual camera support, all in one hand-held ground station for flying and mission planning. It has a payload capacity of 1.5 kg with a flight time of 40 to 45 min (without payload) and has the altitude capability of 120 m.

supporting agriculture at local niche with national perspective. Project intended to provide a seamless, multimedia, multi-ways connectivity to the farmers with the latest agricultural technologies, knowledge base and the pool of large number the subject matter experts. The project is developed by ICAR-Indian Agricultural Statistics Research Institute and Digital India Corporation, MietY, Government of India under a MoU between ICAR and DIC, MietY and implemented in association with Agriculture Extension Division, ICAR. Initially the services have been started in four major states of India viz. Bihar, Madhya Pradesh, Maharashtra and Uttar Pradesh later on in December services were extended to two more states, viz. Andhra Pradesh and Telangana. Subsequently the services of Kisan-Sarathi were made available to all the States and UTs in June, 2022.

A total of 731 KVKs are enrolled with the system, where, more than 3,600 agricultural scientists and subject matter experts are registered with Kisan-Sarathi. Number of training programmes have been organised for the officials of ATARIs and associated KVKs and all the registered Scientists were trained for efficient operation and management of services. The services of Kisan-Sarathi for the farmers is available through an IVR based calling system via toll free numbers 1800-123-2175 and a short number 14,426. Once a registered farmer calls to any of these numbers, his call is directly gets connected to one of the agricultural scientists of associated KVK of his locality. Through this system they can mutually talk in their respective local language to resolve any issue related to agriculture or farming. All the calls made into the system are recorded in the MIS of Kisan-Sarathi and are available for future reference. Till date, more than 46 lakh farmers have been registered with Kisan-Sarathi from more than 1,35,000 villages from all across country. Apart from receiving more than one lakh calls from the farmers, more than 10 crore advisories in the form of SMS has also been sent to the registered farmers by Scientists of KVK via Kisan-Sarathi Platform.

ICAR-Network Program on Precision Agriculture (NePPA): The ICAR-Network Program on Precision Agriculture was initiated by the Council initially with 16 ICAR Research Institutes with IARI as Lead. The program is focused on exploring potential applications of recent developments on technologies related to sensor, IoTs, Drone and ICTs for precision smart agriculture. The major objectives span its scope over soil fertility, crop health, livestock, post-harvest operations, aquaculture and upscaling these using advanced technologies like drones,

variable rate technologies (VRTs) to enhance input use efficiency and optimal production system. Following are the major achievements under this program:

Development of spectral models for quick assessment of different soil attributes: Models were developed using machine learning (ML) algorithms such K-Nearest Neighbour (KNN), Random Forest (RF), Ridge Regression (RIDGE), Quantile regression forests (QRF), Least Absolute Shrinkage and Selection Operator (LASSO), Support Vector Machine (SVM), and Elastic Net (EN). The models were validated and compared and the best pipeline was selected for assessment of different soil attributes.

Development of IoT enabled irrigation scheduling system for Field Crops: IoT (Internet of Things) based Irrigation Water Management System (IWMS) was developed and tested in wheat and chickpea to measure the soil moisture at three different depths, viz. 20 cm, 40 cm and 60 cm. The mobile application pertaining to the irrigation scheduling was also developed in python and is under testing and subsequent debugging.

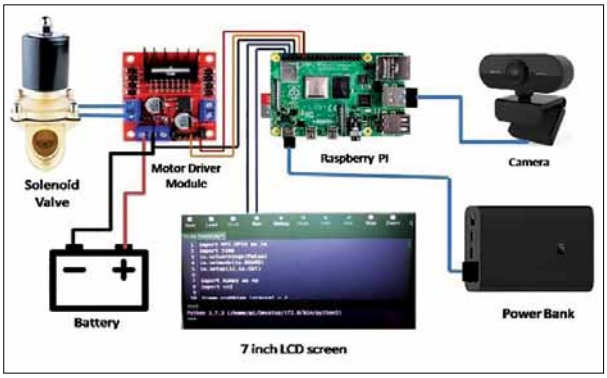
Developing computer vision based variable rate N applicator: A low cost variable rate N applicator was developed using low cost RGB webcam, single board controller (Raspberry Pi), HDMI display with touch screen, memory card and solenoid valve. Instead of proportional control valve solenoid valve has been used. The existing tractor mounted spraying unit has been developed. Four flat-fan nozzles were used and operated by single solenoid valve. Based on this experiment the discharge capacity and operating pressure of proportional control valve will be decided.

Low Cost Smartphone-based Precision Nitrogen Management

An Android app named as Pusa N-manager has been developed for nitrogen management based on image taken from smart phone. In this App, the nitrogen content and chlorophyll content of the leaves of the image taken is analysed on the basis of the RGB channel, a few spectral indices were derived and regressed against the nitrogen content. The Info Crop simulation model was used to determine the ideal leaf nitrogen concentration at a specific crop growth stage. Calculating the top-dress nitrogen dose can be done using the leaf nitrogen deficiency.

Development of Drone based Vertical Water Sampler

One Drone based Vertical Water Sampler has been developed and field validated by team at ICAR-CIFRI in collaboration with ICAR-IARI. The patent application for Drone based Vertical Water Sampler has been filed in Indian Patent Office. The present invention helps in collecting water samples from inland open waters including rivers, reservoirs, wetlands, lakes and oxbow lakes etc. using a remote-controlled Drone based water sampler. This will be useful for inland aquatic ecosystem health monitoring programs of Government, Non-governmental Agencies and Research Organizations.

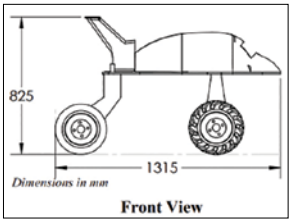


IoT and sensor-based fertigation system for greenhouse tomato: The developed automation system on IoT and Sensor based fertigation

system for green house condition has IoT enabled controller for storage and analysis of sensor data, fertigation control head with venturi arrangement for fertigation management of greenhouse crops like tomato and capsicum. It is evidenced from the result that, the water saving of 14.84%, 12.97% and 9.62% observed in sensor based irrigation with 100% ETc, 80% ETc and 60% ETc respectively.

Development of Robotic Soil Sampler and Applicator for VRT applications: A robotic platform with differential steering system was designed and developed. The robot comprised mainly prime mover (chassis, drive wheels, caster wheel, upper body, gearbox and motors), controller (pixhawk 2.4.8) and sample collection unit.

The soil sampling collection unit was design and fabricated to collect the samples automatically in the field.



Media and information

Media and Information Unit assists in press coverage and public relations showcasing the ICAR technologies through national and international exhibitions and production of documentary films. The Unit prepared and released advertisements through print and electronic media. During the year, four documentary films were produced namely ICAR Technologies, ICAR at a Glance, ICAR Achievements and C. Subramanium Convention Hall. About 51 exhibitions were conducted in different states which included Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Jharkhand, Delhi, Haryana, Himachal Pradesh, Kerala, Assam, Meghalaya, West Bengal, Odisha, Bihar, Punjab and Jammu and Kashmir and India International Trade Fair. These exhibitions were participated by 68 institutes of ICAR. The Information and Publicity Unit under DKMA took the initiative in preparation of Concept note on International Year of Millets 2023 for participation of ICAR through tableau in Republic Day Parade which has been accepted.

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17.

Technology Assessment, Demonstration and Capacity Development

Krishi Vigyan Kendras (KVKs) are mandated for technology assessment and demonstration for its application and capacity development under different farming situations across the country. During the reported year, 7 new KVKs were established taking the total number of KVKs to 731 in the country. Besides lab to land activities for outreach, important programmes such as 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. were taken up to address various challenges of engaging youth in agriculture, brining self-sufficiency in production of pulses and oilseeds, sustainable agriculture, etc.

Technology Assessment

Assessment of the location specificity of technologies developed by National Agricultural Research System under various agro-ecological situations is the core activity of KVKs. Technologies assessed under various crops, livestock, enterprises and women empowerment during the year are briefly presented below.

Crops: A total of 6,198 technological options in various crops were assessed by the KVKs at 14,155 locations through implementation of 31,532 trials at farmers' fields to provide technological alternatives to the identified problems across the country. Major thematic areas were varietal evaluation; integrated nutrient management; integrated pest management; integrated disease management; integrated crop management; weed management; resource conservation technologies; farm machineries; cropping systems; post-harvest technology/value-addition and small scale income generation enterprises. Technologies were also assessed in other thematic areas such as seed production; soil health management; integrated farming system; drudgery reduction; storage techniques; mushroom cultivation; information and communication technology; integrated pest and disease management; fodder and nursery raising; water management; biological control and protected cultivation. Varietal evaluation was the major theme of technology assessment with 1,855 technologies assessed through 7,350 trials at 3,491 locations. This thematic area was assessed by almost all the KVK in the country (644 KVKs). Integrated nutrient management (953 technologies, 5,079 trials and 2,043 locations by 507 KVKs) and integrated pest management (833 technologies, 4,455 trials and 1,746 locations, by 438 KVKs) were the other major thematic areas on which technology assessment was carried out.

Livestock: The KVKs assessed 1,097 technological options pertaining to different thematic areas of livestock production and management at 2,516 locations through 6,210 trials. The thematic areas assessed are nutrition management; animal disease management; livestock production management; feed and fodder management; evaluation of breeds; fish production; processing and value-addition; small scale income generation and composite fish culture. Nutrition management was the major thematic area with 284 technologies assessed through 1,788 trials at 473 locations. Technologies related to management of cows, buffalo, sheep, goat, poultry, pig and fish were assessed for confirming the location suitability of various technological interventions.

Farm and non-farm enterprises: KVKs could test 471 technologies under farm and non-farm enterprises at 1,040 locations through 6,124 trials. Technologies belonged to major thematic areas such as processing and value-addition; mechanization; resource conservation technology; organic farming; entrepreneurship development; mushroom cultivation; drudgery reduction; small-scale income generation; storage techniques; health and nutrition and post-harvest management. Processing and value-addition (85 technologies assessed at 154 locations through 247 trials), mechanization (35 technologies assessed at 26 locations through 190 trials) and resource conservation technologies (33 technologies, 184 trials at 19 locations) were the dominant thematic areas chosen by the KVKs for assessment.

Women empowerment: As part of technology assessment, 371 technologies pertaining to farm women were assessed through 3,222 trials at 756 locations. Health and nutrition (152 technologies assessed through 1,353 trials at 314 locations) and value-addition (96 technologies, 911 trials at 339 locations) were the major thematic areas of technologies assessed with an aim to promote women empowerment.

Frontline Demonstrations

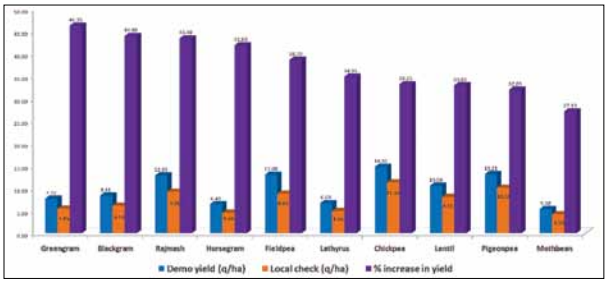
Cluster Frontline Demonstration

A detailed programme was planned, prepared and executed by Division of Agriculture Extension, ICAR, New Delhi on Cluster Frontline Demonstrations (CFLDs) under NFSM, Ministry of Agriculture and

Farmers Welfare, GOI, New Delhi with an objective to demonstrate the production potential of major pulses (chickpea, pigeon pea, lentil, blackgram and greengram) and oilseed (sesame, groundnut, linseed, soybean, mustard, sunflower) crops in pulse and oilseed growing states, viz. Andhra Pradesh, Bihar, Gujarat, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Madhya Pradesh, Uttar Pradesh and West Bengal.

Cluster Frontline Demonstration on Pulses: During the period under report, 17,973.95 ha area was covered under 48,473 demonstrations on pulse crops across the country. In *kharif,* 7,623 ha area (20,594 demonstrations) was covered, while in *rabi* season 8,341.44 ha area (22,822 demonstrations) and in summer season 2,009.39 ha (5,057 demonstrations) was covered.

On national level, the average yield advantage in major pulse crops was recorded as 37.42% however, it was highest in Greengram (46.35 %) followed by Blackgram (44.00%), Rajmash (43.49), Horsegram (41.93), Fieldpea (38.70), Lathyrus (34.95), Chickpea (33.25), Lentil (33.03), Pigeonpea (32.05), Mothbean (27.19). This was mainly due to farmers' awareness, suitable technology interventions and skill developed among farmers by the KVKs.



Yield performance of pulse crops

CFLD on chickpea (PBG-8) at Sambha (Zone-I Ludhiana)

CFLD on Lentil (PL-9) at Roper (Zone-I Ludhiana)


CFLD on Greengram (Virat) Zone-IV Patna


CFLD on Pigeon pea (IPA-203) at Kaushambi (Zone-III, Kanpur)

CFLD on Pigeon pea (PRG 176) at KVK Kalahandi (Zone-V Kolkata)

CFLD on Blackgram (Pratap Udad 1) at KVK Panna (Zone-IX Jabalpur)


CFLD on on Blackgram (IPU 02-43) at KVK Marigaon, Assam (Zone-VI Guwahati)

CASE STUDY

Enhancing Farmers' Income via "Strawberry Cultivation" : A Case Study from Chittorgarh District of Rajasthan

Shri Nemichand Dhakar, a 32 years old farmer, having done Post Graduation, belonging to Sripura village in Nimbahera Tehsil of Chittorgarh district of Rajasthan State, has 6.00 ha cultivable land with two tube wells as well as open well as source of irrigation, besides owning a cattle dairy unit. After completing post-graduation in the year 2014, he started lookingafter his family farms, and realized that… only growing traditional crops like maize, wheat, mustard, gram and groundnut is not profitable; and hence, some innovative enterprise is necessary for enhancement of income. Then, he contacted some agriculture scientists and extension officers, several times, while having thorough discussions regarding various innovative options to enhance farm income. In 2015, he visited KVK, Chittorgarh; and subsequently, he underwent a training on improved cultivation practices of strawberry. In the same year, he started cultivating strawberry in a small area under the technical guidance of Scientists of that KVK. After getting encouraging results, he gained confidence, and extended strawberry cultivation to 1.00 ha in the year 2020. He brought mother plants of three varieties (*Winter Down, Winter Star* and *Sweet Sensation*), imported from California; and planted the same in his field. Afterwards, he was able to produce thousands of plants from runners of mother plants, and planted on raised bed, on mulching sheet, with drip irrigation system in September. He sold strawberry fruits in the market of Delhi, Jaipur, Ahmadabad and other metropolitan cities. He earned a net income of ₹ 11.60 lakh per ha with 5.83 BCR. Other than strawberry production, now he has also raised 2.00 lakh plants of strawberry and earned a gross income of ₹10.00 lakh, by selling of plants to the farmers during 2021. He has branded his strawberry as '*Shiv Shakti'*, and started selling with proper modern-day attractive packing.

Adding an innovative enterprise to his farm has enormously increased his income. With an increased income, he not only has improved and secured his livelihood, but also has generated employment for his family members. He has also improved his social status with more acceptance, recognition and respect as an innovative young farmer, as he is the first farmer in the hilly area of Chittorgarh district to cultivate strawberry, successfully. Now more than 15 farmers from Rajasthan and adjoining state of Madhya Pradesh have been motivated to start cultivation of strawberry, and they approached him for planting materials and cultivation technology. For strawberry cultivation, several farmers visited his farm, and took technical advices regarding cultivation on large scale, on a sustainable basis.

A view of strawberry cultivation by Shri Nemichand Dhakar

A view of strawberries harvested by Shri Nemichand Dhakar

CASE STUDY

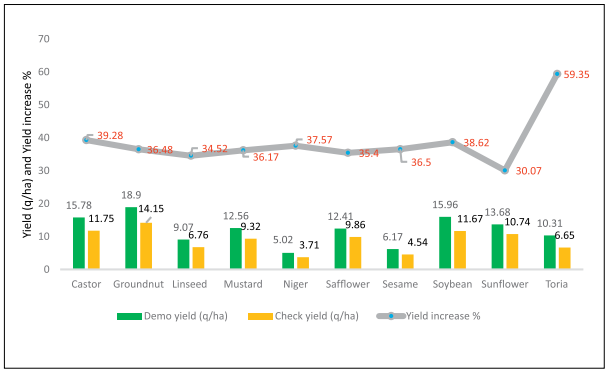
Bio-fortified Wheat Variety DBW-187 (Karan Vandana) : A Successful Cultivation

KVK Bijnour introduced bio-fortified wheat variety DBW 187, rich in iron (43.10 ppm) as compared to other wheat varieties (28.00 ppm), through On Farm Testing during *Rabi*-2019-20 and through Frontline Demonstrations during 2020-21 to 2021-22 at 71 farmer's fields. The average yield at Farmers field was 71.00 q/ha (78.00 q maximum yield per ha.) with cost of cultivation of ₹ 47,516/ha. The average net profit per ha was recorded as ₹ 1,19,825. This variety may be capable for increasing extra net return of farmers due to higher yield with very rich nutritional quality, as compared to other wheat varieties. The area under this variety has now spread to more than 27,500 ha. Farmers are satisfied with the yield of this variety and also claim that it is better in quality.

A view of bio-fortified wheat variety DBW-187 in farmer's field

Cluster Frontline Demonstration on Oilseeds: During reporting period, 18,301.31 ha area was covered under 46,519 demonstrations on oilseed crops across the country. In *kharif* season 6,207.97 ha area (15,141 demonstrations), in *rabi* season 10,414.44 ha area (27,298 demonstrations) and in summer season 1,679.00 ha area (4,080 demonstrations) was covered.

On national level, the average yield advantage in major oilseed crops were recorded as 38.40 % however, it was highest in Toria (59.35 %) followed by Castor (39.28 %), Soyabean (38.62 %), Niger (37.57 %), Sesame (36.50 %), Groundnut (36.48 %), Mustard (36.17 %), Safflower (35.40 %), Linseed (34.52 %) and Sunflower (30.07 %). This was possible due to farmers' awareness, suitable technology interventions and skill developed among farmers by the KVKs activities.



Yield performance of oilseed crops (q/ha) under CFLDs oilseeds (2021-22)

Field day on Rapeseed Mustard, KVK Budgam (J&K)

Demonstration on Niger, KVK Dhubri (Assam)

Demonstration on Soybean, KVK Dewas (MP)

Demonstration on Groundnut, KVK Shriganganagar (Rajasthan)

Other Frontline Demonstrations

A total of 1,58,617 Frontline Demonstrations (FLDs other than CFLDs including 10,0152 FLDs on crops covering 26,225.83 ha area, 17,121 demonstration on farm machineries covering 9,750.39 ha area, 18,880 FLDs on livestock and fisheries, 16,880 demonstrations on other enterprises and 5,864 FLDs on gender-specific technologies for women empowerment were organized.

Cereals: Among 33,588 FLDs on cereal crops, 10,661 FLDs were conducted on 231 technology options on wheat varieties and management technologies in 3,724.04 ha area by 271 KVKs. The average yield in the demonstrations was 12.20 % higher than the farmers' practice. A total of 504 varietal and technology options were demonstrated in 18,848 FLDs in 4,625.52 ha area on rice varieties and technologies by 434 KVKs in which the average yield in demonstration was 21.03 % higher than the farmers' practice. On maize varieties and technologies, 134 KVKs conducted 131 varietal and technology options in 3,616 FLDs and 1,074.76 ha area wherein the yield increase was 25.71% in the demonstrations over farmer's practice. Demonstrations were also conducted on barley and oats.

Millets: Among 3,030 FLDs on millets, the highest number of 48 varietal and technology options were demonstrated on finger millet by 52 KVKs in 1,278 FLDs wherein the average yield was 47.78% higher than the farmer's practice. Varieties and technologies on pearl millet (35) and sorghum (35) demonstrated in 633 and 500 FLDs showed 27.03 % and 28.57 % higher average yield than farmer's practice.

Pulses (other than CFLDs): Among the 12,206 FLDs on 533 varietal and production technologies on pulses 3,463 FLDs were on chickpea (27.62 % higher average yield than farmer's practice), 2,461 FLDs on blackgram (28.73.0 % higher average yield than farmer's practice), 1,911 on greengram (29.99% higher average yield than farmer's practice), 1,702 were on Lentil (33.92 % higher average yield than farmer's practice) and 1,415 on pigeon pea (26.26 % higher average yield than farmer's practice).

Oilseeds (other than CFLDs): A total of 9,353 FLDs were conducted on 439 varieties and management technologies of oilseed crops out of which 2,311 were on mustard with 37.75% higher yield than farmer's practice, 2,088 on rapeseed with 28.84% higher yield than farmer's practice, 1,636 on soybean with 13.38% higher yield than farmer's practice, 1,507 on groundnut with 22.09% higher yield than farmer's practice.

Horticultural crops: Altogether, 27,215 FLDs were conducted on 1,635 varieties and technologies of horticultural crops comprising vegetables (18,514), fruits (3,628), spices (3,071), flowers (594), medicinal and aromatic crops (143) in 5,342.1 ha area. The increase in average yields recorded in demonstrations as compared to farmers' practice was 30.11% in vegetables, 27.54% in fruits, 25.20% in flowers, 26.63% in spices and condiments, and 40.13% in tuber crops over the farmers' practices.

Commercial crops: A total of 1,530 FLDs including 477 in sugarcane were conducted in an area of 697.4 ha through KVKs. The average yield increase in the demonstrations plots was 15.67% in sugarcane as compared to farmer's practice.

Fibre crops: A total of 1,074 FLDs were conducted on cotton and jute varieties and technologies wherein the average yield was 16.52% higher than the farmer's practice.

Fodder crops: Demonstrations on crops such as berseem, maize, sorghum, Napier grass, etc., were conducted in 3,738 farmers' fields covering an area of 495.3 ha. The average yields in demonstrations were 35.23% higher than the farmer's practice.

Hybrids: To achieve higher harvest index in crops, KVKs conducted 7,973 FLDs on 310 on hybrids covering an area of 2,372 ha in cereals, millets, oilseeds, pulses, fodder crops, commercial crops and horticultural crops. In cereals comprising rice and maize, 2,727 FLDs were conducted in an area of 942.6 ha to demonstrate the potential of various hybrids. Demonstrations on hybrids of oilseeds were conducted across the country covering 293 ha. A total of 3,031 FLDs were conducted on various vegetables, fruits, flowers and spices in 578.8 ha area. In hybrid cotton 916 demonstrations were conducted in an area of 391 ha where the average yield increase was 14.3% over the farmer's practice.

Farm mechanization: A total of 17,121 demonstrations were conducted on 777 technology options on improved tools and farm implements including drudgery reduction technologies covering an area of 9,750.37 ha. The highest number of 6,654 demonstrations were on sowing and planting machineries and 3,268 on plant protection machineries and 3,155 on harvesting tools and machineries.

Livestock and fisheries: Demonstrations on dairy animals, poultry, sheep and goat, poultry including chicken, quail, turkey and duck, piggery, rabbit etc., were carried out in 16,983 farmers locations and 1,617 demonstrations were conducted on fisheries.

Enterprises: A total of 16,880 demonstrations on 20 enterprises like mushroom cultivation, apiary, sericulture, value-addition, vermicompost, nursery etc., were conducted in which 23,383 enterprise units were established. On women and children, 5,864 demonstrations were conducted on various enterprises like value-addition, kitchen garden, nutrition etc., for 51,187 beneficiaries.

Rice sowing with Happy seeder

Demonstration on cauliflower cultivation

Capacity Development

A total of 21.16 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 69,550 training programmes including the sponsored training courses.

Farmers and farm women: Training courses (53,593) on various technologies benefitted 16.84 lakh farmers and farm women out of which 11.0 lakh (65.64%) participants were from other classes while 5.78 lakh (34.31%) were from SC/ST category. These courses targeted productivity enhancement and cost reduction of field crops (23.20%), horticultural crops (16.65%), plant protection (13.27%), livestock production and management (11.14%), soil health and fertility management (10.20%), empowerment of rural women including home science (12.82%), agricultural engineering (3.95%), capacity building for group actions

CASE STUDY

Sustainable Income through "Fish Cultivation"

The KVK, Bhagalpur (Bihar) conducted six skill training programmes on different aspect of fish seed production, and established 69 commercial fish production units and two hatchery units, besides conducting one exposure visit of farmers at ICAR-CIFRI, Barrackpore, Kolkata (West Bengal). As a result of these sustained efforts on the part of Scientists involved, now, these farmers are able to produce 3 lakh fish fingerlings @ 40 q/year of fish production. The fish fingerlings and fish are marketed through Agri Entrepreneur Service Centre (AESC), Community Managed Resource Centre (CMRC) and FPOs, local SHGs, and the JEEVIKA group, while being facilitated by the KVK and the state government. As of now, those farmers have been getting a net income of ₹ 9.75 lakh, annually.

Front view of fishing

Fish fingerlings supply

CASE STUDY

Farm Woman Sets Example through "Organic Cultivation of Broccoli"

Smt. Otok Nopi Taggu is a school drop-out and hard working farm woman belonging to Upper Siang District of Arunachal Pradesh. She has taken up different agricultural and horticultural practices since the last 10-15 years with success, and has established herself as a renowned progressive farm woman in the district. With the intervention of KVK, Upper Siang, she has started organic cultivation of broccoli since last two and half years; and her income has become manifold. She also underwent one training on package of practices of Broccoli and demonstration on nursery raising of Broccoli organised by KVK, Upper Siang, Arunachal Pradesh. To encourage and as a support, seeds of broccoli variety (*Solan Green*) were provided to her, coupled with other means, viz. regular field visits, advisories and proper monitoring. She cultivated exotic vegetable Broccoli in 1.00 ha with organic practices, wherein she harvested 5,000 kg of Broccoli and got a net income of ₹ 1.74 lakh with 3.35 BCR. She sold Broccoli at a price of ₹ 50/kg and Broccoli leaves at ₹ 20/bunch. She expressed that her income has been increased as a result of good production. As broccoli not only tastes delicious, but also has many health benefits; and hence, there is a demand of broccoli in the market. This shows that cultivation of broccoli is very feasible in Upper Siang district of Arunachal Pradesh, as it is economically viable and provides a faster return.

A view of farm of Smt. Otok Nopi Taggu

Selling produce in local market by Smt. Otok Nopi Taggu

(5.65%), production of inputs (3.86%), fisheries (2.70%) and others including agro-forestry (1.69%). Out of these training courses 43.31% were organized on-campus while rest (56.69%) were organized off-campus. Within field crops, integrated crop management was the leading theme in which 24.12% of courses were organized followed by weed management (9.29%), seed production (7.98%), cropping systems (6.32%), integrated farming (6.17%), resource conservation technologies (6.68), nursery management (3.22%), crop diversification (5.05%), water management (5.41%) and production of organic inputs (5.11%). Among the training courses on horticulture, vegetable crops constituted 52.15% while proportion of courses on fruits was 28.75%. However, the respective share of training courses on medicinal and aromatic plants, spices, tuber crops, plantation crops and ornamental plants was less than 19.10%.

CASE STUDY

"Backyard Rabbit Farming" for Income-generation and Self-employment

Smt. Thenurovino, a graduate, is a progressive farmer from Khonoma village of Kohima District, Nagaland. She rears pig, poultry and cultivates various seasonal crops, but without much remuneration, as the germplasm is poor; and she was also not aware of various farming options, which could provide her employment and provide a source of income for livelihood. KVK, Kohima has been regularly conducting trainings and various extension activities at Khonoma village. Smt. Thenurovino happened to be a beneficiary in one of the trainings on "Rabbit Farming", and expressed her interest in "Rabbit Farming", since then. When the same KVK conducted a Frontline Demonstration on "Broiler Rabbit Farming", she was also selected as one of the beneficiaries. During the demonstration, bunnies and cages were provided to all the farmers as a part of the programme and timely monitoring was done till the end of the programme. After the FLD, Smt. Thenurovino established "Backyard Rabbit Farming" unit under the technical guidance of KVK Scientists.The outcome was assessed for one year, and the results were found to be very encouraging. During this period, she sold 220 nos. of bunnies (@₹350/- per bunny), with a gross income of ₹ 77,000. Excluding the initial investment on the housing and equipment, she could get a net profit of about ₹ 70,000. More farmers have started rearing rabbit in their villages, as the investment and management is less as compared to the other livestock farming. She continues to inspire and encourage fellow villagers to adopt modern farming techniques for income and self-employment.

A view of backyard rabbit farming unit of Smt.Thenurovino

Rural youth: Training courses (10,908) for the skill development of rural youth were organized for 2.69 lakh participants out of which 93,513 (35.28 %) were the young women during this year. The highest proportion of training courses under this category were imparted on mushroom production (9.84%) followed by value-addition (6.86%), seed production (4.31%), nursery management of horticulture crops (5.36%), vermi culture (4.84), dairying (4.47%), bee keeping (6.30), integrated farming (5.45) and production of organic inputs (5.00%). There were a large number of other areas on which relatively smaller number of training courses were organized for the rural youth. These trainings were conducted mainly on-campus (63.73%).

Extension personnel: Capacity development of 1.62 lakh extension personnel was carried out through 5,049 courses in the country. The proportion of female participants in these programmes was 30.90%. Different extension functionaries working both in government and non-government organizations for the development of agricultural section in the country were included in these trainings. The trainings mainly focused on agricultural technologies aimed at knowledge enhancement in field crops (12.96%), integrated pest management (13.49%), integrated nutrient management (9.24%), protected cultivation technology (5.69%), information networking among farmers (1.13%) and women and child care (4.56%) related technology and information management of farm animals, women and child care, livestock feed and fodder production, protected cultivation technologies and information communication technology (ICT) applications were other areas under such training courses. Higher proportion of trainings for extension personnel were organised on-campus (65.01) compared to the off-campus (34.99%).

Demonstration on nutrition garden

Value-addition

Extension Programmes

As an appropriate technology and its dissemination is equally important in current information era, KVKs in the country are actively involved in organization of various extension programmes to reduce the time lag between generation of technology at the research institution and its transfer to the farmer fields for increasing production, productivity and income from the agriculture and allied sectors on a sustained basis. During the year, KVKs organized a total of 5.68 lakh extension programmes through different methods and means, viz., advisory services, diagnostic and clinic services, celebration of important days, exhibitions, exposure visits, ex-trainees sammelan, farm science club conveners' meet, farmers' seminar, farmers' visit to KVK, field days, film shows, group meetings, kisanghosthi, kisanmelas, lectures delivered as resource persons, mahilamandal conveners' meetings, method demonstrations, plant/animal health camps, scientists' visit to farmers' field, self-help group meetings, soil-health camps, soil-test campaigns, workshops and others, wherein latest technologies related to agriculture and allied sectors were disseminated among 160.85 lakh participants of which 157.79 lakh farmers and 3.07 lakh extension personnel. Further, KVKs are in the forefront for effective utilization of electronic and print media to have wider coverage of technology dissemination wherein organized 2.27 lakh extension activities in the form of TV programmes, radio talks, CDs/DVDs, extension literature, newspaper coverage, popular articles, research articles, training manuals, technical bulletins, leaflets, folders and books/ booklets for the benefit of a large number of farmers, extension personnel and other stakeholders.

Field visit

Kisan Sanghoshti

CASE STUDY

Empowering Small and Marginal Farmers through FPO

As a part of convergence, KVK Karda, Washim (Maharashtra) implemented a project on formation of "*Technology Transfer Clubs*" (TTCs) funded by NABARD in its cluster villages. Since 2011-12, for the next three-year period, NABARD sanctioned a Pilot project on'*Augmenting Productivity of Lead Crops/Activities'* through adoption of sustainable agricultural practices in five adopted villages, covering 2,000 farm families and an area of 6,071 ha. One of the important activities of this project was that all the beneficiary farmers should be part of the formation of farmers' groups. Immediately after the successful completion of the "*Lead Crop Project"*, in the year 2015, NABARD sanctioned another project on "*Promotion of Farmers Producers Company's* (FPCs)" for a three-year period to KVK, Karda, Washim (Maharashtra). The "*Lead Crop Project"* has shown encouraging results; and more than 750 farmers have been mobilized into village-level Farmer's Interest Groups (FIGs), which have been federated and accommodated as a shareholder in Rishiwat Farmers Producers Company Ltd. in the year 2016. Seed Production, Processing and Marketing are major core activities of RFPCL in the selected cluster under the NABARD project. Initially, as per deliverables on a specified timeline, KVK has conducted an awareness programme as well as farmers' mobilization activities in the identified cluster, followed by registration, business plan preparation and capacity buildings of all stakeholders. Soon after completion of eligible activities, establishment of a Seed processing plant of 4 TPH capacity was sanctioned by Agriculture Department under NFSM and Turmeric Processing unit under ATMA-MACP Project. To store the seed FPC has constructed a warehouse of 10,000 metric tonnes capacity under the POCRA Project.

Rishiwat Farmers Producers Company Ltd. have undertaken seed production of major crops and equipping their shareholders to become certified seed producers. Growing certified improved seeds is a profitable business enterprise for RFPCL. A total of 1,640 farmers, covering 175 villages of Rishiwat FPO have been able to produce 11,209 q of seed of different crops like Soybean, Blackgram, Greengram, Pigeonpea, Chickpea and Wheat, which were sold so far, during the period of 2017-18 to 2020-21, with a net profit of ₹ 81.37 lakh, including payment of ITR. To improve the availability of working capital and development of business activities, the Bank of Baroda (BOB), Washim Branch has sanctioned 1.0 Crore as a Cash Credit limit to RFPCL. In this FPO, 50% of the profit goes to the farmers, while 10% was utilized for an operational cost of FPO and 40% for quality improvement and infrastructure development of FPO. RFPCL has made vast quantity of seed available in neighbouring and nearby villages. To meet the seed demand of farmers during lock down, RFPCL also dropped seed bags at farmer's door steps, and provided seed to the farmers well-in-time for planting. RFPCL has made available other critical agricultural input and soil testing services to the farmers. FPO is gaining support and confidence from farmers which is reflected in its membership.

State Level 1st Prize by NABARD


Direct marketing at farmers doorstep

Production of Technological Products

KVKs produced technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefited 11.18 lakh farmers in the country.

Seeds: During the year, 1.76 lakh seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fiber crops, were produced and provided to 2.89 lakh farmers.

Planting materials: Total of 497.40 lakh quality planting materials of elite species of commercial crops, vegetables, fruits, ornamental, medicinal and aromatic crops, plantation crops, spices, tuber crops, fodder and forest species were produced and provided to 5.01 lakh farmers.

Bio-products: Bio-products, namely, bio-agents (998.59 q), bio-pesticides (1,455.16 q), bio-fertilizers (23,767.38 q), vermin compost, mineral mixture etc., were produced and supplied to the extent of 42,302.87 q and benefiting 2.71 lakh farmers.

Livestock, poultry and fish fingerlings: A total of 298.32 lakh fingerlings, improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 56,203 farmers. Different strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 44,170 farmers. Improved breeds of pigs were provided to 729 farmers. KVKs also enabled 105 farmers to establish small rabbit rearing units by providing 915 rabbits. A total of 289.24 lakh fish fingerlings were produced and supplied to 9,586 farmers.

Soil, Water and Plant Analysis

The KVKs tested 3.10 lakh samples including 2.64 lakh soil samples, 8,368 plant samples, 37,956 water samples and 383 other samples like fertilizers, manures, food etc. benefiting 3.12 lakh farmers of 50,914 villages by providing suitable advisories based on analysis to them. An amount of ₹ 227.03 lakh was realized as analytical charges of which 201.89 lakhs was from soil testing services. A total of 2.22 lakh Soil Health Cards have been issued to farmers.

CASE STUDY

Multi-Layer Farming Systems (Multiple Cropping)

Shri Akash Chaurasiya belongs to a marginal farmer's family in Tilli village of Sagar District of Madhya Pradesh. After being trained at KVK, Sagar, he adopted multilayer farming system with organic farming, in which he grows at least four to five crops in the same field, like ginger, ivy gourd, leafy vegetable, papaya and potato at the same time. Ginger is planted at the depth of 2.5 inches and width of 6 inches under the surface, as the first crop taking in the month of February. Then he grows any one of the leafy vegetables like Amaranthus or Spinach or Coriander etc. densely on the surface as second crop at the same time, which acts as green mulching and prevents the growth of weeds and moisture. As a third crop, he grows specially ivy gourd (Kundru), having a distance of 5-6 feet from each other on the wire net, locally-made from bamboo and grass, and constructed at a height of 6.5 feet from the surface level. The structure provides protection and partial shade to other crops like ginger and leafy vegetables for better growth at the same time in the month of February. Hence, all three crops are grown at the same time, with the same cost of labour& others expenses materials. As the fourth crop, he grows papaya in the month of April, which gives fruit above the net. After digging of ginger in September-October, potato is also planted in the month of October as a fifth crop. During this time, he sells ginger (as an off-season crop) at a higher price, that is ₹ 60 to 100 per kg, in the market. All of these crops were grown on wire constructed (MANDAP) which are fixed parallels on the bamboos, having a distance of 1.5 feet from each other. So, in this way, by growing of four to five crops together, then it can have 3-4 times more earning. Total expenditure on bamboo and wire-made structure, running up to five to six years, happened to be ₹ 1,50,000/acre, that is, ₹ 30,000/year. Total cost of cultivation of crops was ₹ 2,05,000 for cultivation of all crops, viz. Ginger, Ivy gourd (Kundru), Leafy vegetables (Amaranthus/ Spinach/Coriander/Fenugreek etc.), Papaya and Potato per year per acre. The net income obtained, thus, was found to be ₹ 4,95,000/acre with 3.41 BCR. Besides income, four-layer multiple cropping model gave other benefits also, such as, reduced insect-pest, no effect of climate change (i.e. from frost cold and heat waves etc.), and less requirement of manures due to multi crops being grown at the same time.

A view of multi crops in four layer farming system

A view of leafy vegetables before emerging of ginger crop in four layer farming system

Technology Backstopping to KVKs

At national level there are 53 Directorates of Extension Education (DEEs) in the SAUs/CAUs those played a crucial role in technological backstopping to KVKs of the country. During the period under consideration, the DEEs organized 1,021 capacity development programmes for updating the technical knowhow of KVK personnel in India. The DEEs facilitated technological backstopping for KVKs by conducting 1,134 training programmes, 508 field days, 368 farmer scientist interactions, 53 soil health camps, 98 kisanmelas, 163 kisangoshties and 127 technology week celebrations. Moreover, monitoring of KVK interventions (319), *rabi* and *kharif* campaigns (82), animal health camps (48), diagnostic visits (434) and technology exhibitions (105) were also taken care by the DEEs during the period reported upon. The officers of DEEs also delivered 622 lectures, 82 TV talks and 542 radio talks while 6,970 news items appeared in newspapers as a component of technology backstopping for the KVKs. During the period under consideration, a total of 20,248 farmers visited DEEs of SAUs/CAUs for getting improved technological support and inputs.

Vermi compost production

Agricultural Technology Information Centre

There are 47 Agricultural Technology Information Centres (ATICs) in the country which are functioning as single window delivery system in the country in order to serve a very important purpose by providing technology information, advisory services and technological inputs to the farmers. During 2021-22, 4.33 lakh farmers visited ATICs for obtaining solutions related to their agricultural problems and purchasing crucial farm inputs. Moreover, ATICs provided information on various aspects of farming to 1.76 lakh farmers through various modes such as personal communications and print and/ or electronic media during this period. Overall, 1.63 lakh farmers were provided 1.5 lakh q disease-free seed of various crops along with 64 lakh improved plantlets/seedlings, 18,659 poultry birds and 1.14 lakh q bio-products by all the ATICs of India. In addition, 30.19 lakh farmers benefited from technological services provided by various ATICs. The ATICs also provided/facilitated various services,

viz. Soil Health Cards (4,115 farmers), Kisan Call Centre (2,02,552 farmers' calls), postal services to farmers (7,984), Mobile Agro Advisory (23.90 lakh) and special extension programmes (54,285).

Special Programmes and Projects

Attracting and Retaining Youth in Agriculture: Attracting and Retaining Youth in Agriculture (ARYA) project is operational in 100 KVKs. During the year, 4,340 entrepreneurial units related to mushroom production, fruits and vegetable processing units, horticulture nursery, protected cultivation, fish farming, poultry, goat farming, piggery, duck farming, bee keeping and vermicomposting units were established benefiting 6,610 rural youth. KVKs have organized 857 training programmes benefiting 19,213 youth. Nearly 34% trained rural youth established micro-entrepreneurial units in rural areas which benefited them to get net income ranged from ₹ 31,080 to ₹ 539,699/unit/annum across the different entrepreneurial units.

National Innovations on Climate Resilient Agriculture: Technology Demonstration Component (TDC) of NICRA (National Innovations in Climate Resilient Agriculture) which aims at enhancing resilience of Indian agriculture and making Indian farmers more adaptive to climatic vulnerabilities has been implemented through 151 Krishi Vigyan Kendras (KVKs) in climatically most vulnerable districts of the country as per the latest risk categorization. Climate smart technologies encompassing Natural Resource Management, Crops and Livestock modules have been demonstrated in adopted villages as a package to suit the resource and weather related constraints of different farming system typologies of the village along with institutional interventions like Village Climate Risk Management Committee (VCRMC), Custom Hiring Centers (CHCs), fodder bank and seed bank. Capacity building and extension activities are also a part of TDC NICRA to bring larger awareness on climate resilient technologies and to instill climate literacy among farmers.

During the year under report 6,477, 13,931 and 7,187 demonstrations were conducted covering 5,695.81, 6,807.6 and 265.65 ha of area under NRM, Crop and Livestock modules respectively. At the same time 2,038 capacity building programmes and 2,874 extension activities were taken up for the benefit of 27,816 and 2,44,561 farmers respectively for bringing awareness on climate resilient technologies and to enhance climate literacy. Under TDC-NICRA emphasis

Walk-in-tunnel off season vegetable production unit
(KVK Jaintia Hills, Meghalaya)

Mushroom Production unit established under ARYA Programme
(KVK Kannur, Kerala)

Poultry unit established under ARYA programme
(KVK Lungeli, Mizoram)

Pepper Nursery Unit Established Under ARYA Programme
(KVK Kannur, Kerala)

Initiation of Custom Hiring Center under NICRA in KVK,
Tuensang, Nagaland

CASE STUDY

Profitable Nursery through "Mini-Shade Net"

Shri M. Sankara Rao is a marginal farmer, belonging to a remote village of Naiduvalasa of Rambadrapuram Mandal of Vizianagaram district in Andhra Pradesh. He is an ex-trainee of KVK, Vizianagaram. Having gained knowledge and skill in nursery, he established nursery unit with "*mini-shade net*" under the technical guidance of KVK faculty. He raised seedlings of different vegetables and papaya under *mini-shade net* (60 sq m) and produced high quality virus-free papaya seedlings (2,500) and vegetables seedlings, viz. Tomato (5,000), Brinjal (5,000), Chilli (5,000) during May 2021 to October 2021, with which, he received a net income of ₹ 25,700. Farmers from the neighbouring villages got attracted with the benefits gained by protected shade-net nursery production; and accordingly, approached KVK, Vizianagaram for further guidance to adopt the technology.


A view of nursery unit of Shri M. Sankara Rao with mini-shade net

CASE STUDY

Cultivation of Dragon Fruit in Dryland Area

Dragon fruit is a tropical fruit that has become increasingly popular in recent years. Though people primarily enjoy it for its unique look and taste, evidence suggests its health benefits as well. Dragon fruit is the fruit of a variety of cactus species. It has a unique appearance, sweet taste and crunchy texture. The dragon fruit contains multiple antioxidants, that are beneficial for good health. Dragon fruit also contains many vitamins and minerals, that are important for a healthy body.

Shri Pavankumar Basappa Rangatti, 21 years of age, is a young graduate hailing from Ratnapur village, Tikota Taluk, Vijayapur district of Karnataka. Being the only son, he did not want to leave his parents alone. After his graduation, he was in dilemma regarding profession to be taken up. Browsing through the newspapers, he read about the trainings being conducted by Krishi Vigyan Kendra, Vijayapura-I on organic farming, especially meant for individuals aged below 35 years; and he attended one such training. Subsequently, he adopted dragon fruit cultivation in his dry land area, under the technical guidance of KVK, Vijayapura-I. Earlier his father was growing grape, which was a costly affair. Looking into the expenses on cultivation of grapes, his father too supported him in his new venture. He brought 4,000 saplings of both white and red varieties of dragon fruit from Maharashtra, and took the risk of planting them in his 2 acres of land. He harvested the fruits after one and half years. He sells the fruits at the rate of ₹ 150-180 per kg and sapling at the rate of ₹ 20 per sapling. In 18 months only, he earned ₹ 1.25 lakh by spending ₹ 3.00 lakh. Gradually, his profit increased to ₹ 3.80 lakh in second year, ₹ 6.00 lakh in third and ₹ 8.00 lakh in fourth year by selling the fruits. From the sale of saplings, he has earned ₹ 3.00 lakh. Thus, as on today, he has earned a net profit of ₹ 11.00 lakh, and is very much confident of earning higher profits in future too. Looking into the profits/benefits and realizing the importance of dragon fruit, farmers of different taluks and districts from surrounding areas like Muddebihal, Torvi, Atalatti, Nidgundi, Dhavalgi, Hoskote, Kadur have purchased seedlings from him and started dragon fruit farming in their respective fields.


A view of dragon fruit orchard and sapling unit of Shri Pavankumar Basappa Rangatti

has been laid largely on forging convergence with ongoing government schemes in the respective district for saturating more number of villages with promising climate smart technologies.

Mera Gaon Mera Gaurav: An innovative initiative *Mera Gaon Mera Gaurav* aimed to promote the direct interface of scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers with required information, knowledge and advisories on regular basis by adopting villages particularly small and marginal farmers. During interaction with scientists farmers put forth their issues apropos technological availability, loans, market price, extension programmes and support provided by different agencies, etc.

The programme was implemented by 127 institutions (ICAR institutes and SAUs) through 1,054 groups of 4,315 scientists during the reporting period. They covered 3,680 villages, conducted 37,982 field activities including awareness, demonstrations, training, meetings, etc. and 27,958 message advisories sent by which 5,05,303 farmers benefited.

Farmer FIRST: Farmer FIRST Programme is a flagship programme initiated by ICAR to move beyond production and productivity; to privilege the smallholder agriculture; and complex, diverse and risk prone realities of majority of the farmers through enhancing farmers scientists interface. A total of 36,496 demonstrations were conducted, 2,649 extension programmes were organized, 54,492 animals (livestock and poultry) were benefited and 79,731 farm families were covered in all modules during the reporting period.

Beekeeping

Pigeonpea cultivation in bed planting

Out of the total demonstrations conducted, highest number of demonstrations 11,443 were conducted in crop module followed by 11,005 demonstrations in livestock and poultry; 8,444 demonstrations in horticulture module; 3,894 demonstrations in NRM module and 1,710 demonstrations in IFS module were conducted.

Out of the total farm families, 13,472 farm families in crop module; 6,656 farm families in NRM module; 11,766 farm families in horticulture module; 10,985 farm families in livestock and poultry module; 2,132 farm families in IFS module and 34,720 farm families in extension activities were benefited.

Knowledge System and Homestead Agriculture Management in Tribal Areas: Knowledge System and Homestead Agriculture Management in Tribal Areas (KSHAMTA) has been initiated to channelize the Tribal Sub Plan fund of ICAR institutes for Development of Tribal Agriculture. KSHAMTA is being implemented in 125 tribal districts of the country through KVKs.The activities comprises training, OFTs, FLDs, extension activities, production of seeds, planting materials, livestock strain, fingerlings testing of soil, water, plants and manures etc. A total of 4,634 no. of farmers trainings were conducted by the TSP KVKs which were attended by 1,21,809 farmers. In addition to that, 2,168 trainings were organized exclusively for women farmers which benefitted 55,597 no. of farmers. Apart from that 1,100 and 593 no. of trainings were conducted for rural youths and extension functionaries which aided 29,238 and 13,757 rural youths and extension functionaries respectively. A total of 6,874 farmers were involved in On-farm Trial, 31,677 participated in Frontline Demonstrations and 3,948,817 no. of mobile agro-advisories were disseminated to the farmers. The production of planting materials, livestock strains and fingerlings comprises 15,067.20 lakhs, 59.66 lakhs, 9.98 lakhs and also 9,259.61 q seeds were produced all over the country. A total of 26,059 numbers of testing of soil, water, plant manures samples were identified all over India.

Nutri-sensitive Agricultural Resources and Innovation: Nutri-Sensitive Agricultural Resources and Innovations (NARI) Programme is a flagship programme initiated by ICAR at national level. Nutrition-sensitive agriculture is an important part of ending malnutrition through multi-sectoral action. Nutrition-sensitive agriculture puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies. This approach stresses the multiple benefits derived from enjoying a variety of foods, recognizing the nutritional value of food for good nutrition, and the importance and social significance of the food and agricultural sector for supporting rural livelihoods. The overall objective

of nutrition-sensitive agriculture is to make the global food system better equipped to produce good nutritional outcomes. Nutrition-sensitive agricultural approach through homestead nutrition garden aims to make food more available, accessible, diverse and nutritious.

During the year, KVKs conducted On-farm trials, technology demonstrations, trainings and various extension activities under NARI programme. A total of 16,681 nutri-gardens were established with 30,310 farm families were benefited under FLD and OFT activity.

Similarly, 211 demonstrations (in 540.00 ha) were conducted on nutri-rich bio-fortified varieties of different crops (cereals, millets, pulses, oilseeds and tubers) to improve nutritional status to the farming community benefited 2,442 farmers. KVKs also conducted 677 demonstrations on value-addition of different crops, viz cereal, millets, vegetables and fruits and 8,838 farm women benefited.

KVKs organized different training programmes and extension activities under different areas like promotion of nutrition garden, nutri-*thali*, value-addition, bio-fortified crops, etc. Total 2,657 training programs were organized benefitted 81,633 participants and 4,161 extension activities were organized benefitted 1,37,674 participants at farmers' fields for creating awareness on nutrition literacy.

Celebration of Poshan Maah

Poshan Thali

Scheduled Castes Sub Plan (SCSP): SCSP is sponsored by the Ministry with the objective to ensure flow of targeted financial and physical benefits for the development of Scheduled Castes. Under the strategy, States/UTs were required to formulate and implement Special Component Plan (SCP) for Scheduled Castes as part of their Annual Plans by earmarking resources. At present 19 States/UTs having sizeable SC population were implementing Schedules Caste Sub-Plan.The activities comprises under SCSP, i.e. training, OFTs, FLDs, extension activities, production of seeds, planting materials, livestock strain, fingerlings testing of soil, water, plants and manures etc. A total of 6,811 no. of farmers training were conducted by the SCSP KVKs which were attended by 1,18,485 farmers. In addition to that, 3,095 trainings were organized exclusively for women farmers which benefitted 1,14,252 no. of farmers. Apart from that 1,203 and 706 no. of trainings were conducted for rural youths and extension functionaries which aided 27,514 and 14,967 rural youths and extension functionaries respectively. A total of 7,544 farmers were involved in On-farm Trial, 56,431 were participated in Frontline Demonstrations and 1,06,25,763 no. of mobile agro-advisory were disseminated to the farmers. The production of planting materials, livestock strains and fingerlings comprises 42.48 lakhs, 52.63 lakhs, 25.70 lakhs and also 12,989.53 q seeds were produced all over the country. A total of 55,283 numbers of testing of soil, water, plant manures samples were identified all over India.

Pulses seed-hubs: Seed-hubs have been set-up at 95 KVKs for production of quality seeds of major pulse crops. During the year, 42,835.07 q seeds of pigeon pea, blackgram, greengram, lentil, chickpea, field pea and lathayrus were produced and made available to farmers.

Crop Residue Management: The north-western India especially, Punjab, Haryana and western Uttar Pradesh, commonly known as the seat of Green Revolution in India, immensely contributed to the national food security mainly through producing paddy and wheat. However, intensive cultivation practices in this part of the country have also led to burning of paddy straw due to short window (15-25 days) for timely sowing of ensuing *rabi* crops (mainly the wheat). The enormous burning, within a short span of 15 days, leads to atmospheric pollution, massive nutritional losses and deterioration of physical and biological health of the soil. Taking this problem into consideration the Government of India decided to launch a Central Sector Scheme on "Promotion of Agricultural Mechanization for *in-situ* management of crop residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi" in 2018. ICAR entrusted to execute Information, Education and Communication (IEC) component of this scheme through 60 KVKs of Punjab, Haryana, Delhi and Uttar Pradesh.

In the IEC activities carried out by the KVKs during 2021-22 more than 64,000 farmers participated in 881 awareness camps organized at different district, block and village level. Capacity building of 6,476 farmers, tractor and machine operators, and custom hiring centre owners developed by organising 225 training programmes of 5-days duration. About 25,000 farmers

were mobilised in 60 Kisan Melas organized by KVKs on theme Crop residue management. School and college students were recognised as prospective stakeholders to reach out to their farming parents, neighbours, and villagers to encourage them to use the latest agricultural residue management technology. Many schools and colleges were involved in creating the awareness about crop residue In-situ management and 37,738 students were sensitised by organising 537 activities like essay completion, painting, debate, etc. Demonstrations on crop residue management using CRM machinery were held at important locations on more than 20,000 ha, whereas, more than 3,000 demonstrations conducted on decomposer technology. KVKs also organized 155 exposure visits, 197 field days/harvest days in which more than 6,900 and 12,000 farmers were mobilised, respectively, during the period under consideration.

Integrated Farming System (IFS): It commonly refers to agricultural systems coupled or integrated with livestock, fisheries etc. and this is also referred to as integrated bio-systems. In this system, there exists an inter-relation between the different farming enterprises and it highly emphasises on waste management or resource management in such a way that the waste from one enterprise becomes an input for another enterprise. It was popularized all over the country because of the fact that it is highly feasible for small and marginal farmers which prevails over 82% of the total farming population in the country. IFS of different component combination were popularized through all the KVKs in the country and there are 3,778 IFS units established spanning an area of 88,406.19 ha during 2021. Under IFS total 5,894 demonstrations and 9,512 trainings were conducted for 75,058 and 1,17,010 farmers respectively during 2021.

Initiatives by KVKs during COVID-19 Pandemic: KVKs across the country made focussed attempts to help farming community cope with various constraints posed by Covid 19 during day-to-day farm operations and also in handling farm produce post harvesting. Attempts were made to brining more awareness on Covid appropriate behaviour, implementing field operations and marketing strategies to be deployed for effecting disposal of farm produce.

Advisories on crop and livestock production/ protection technologies for *rabi* and summer 2021-22 and *kharif* 2022 were received from KVKs, complied at ATARI level and at National level, uploaded in ICAR website and disseminated by KVKs in their operational districts through extensive use of ICT platforms and social media. The advisories were translated in 15 different regional languages and circulated among farmers through KVKs.

A total of 4,835 awareness programmes were conducted by KVKs across the country to bring awareness on covid appropriate behaviour among 4.44 lakh farmers during the period under report. Crop (35,378) and livestock (11,182) related advisory was given by KVKs during the crop season for the benefit of 7.38 lakh and 2.20 lakh farmers respectively. A total of 2,351 different interventions were undertaken by KVKs to facilitate marketing of farm produce benefitting 5.42 lakh farmers. KVKs also undertook various Covid related interventions like publication of literature, use of YouTube channel and other social media platforms for helping farmers overcome restrictions posed by the pandemic benefitting about 5.02 lakh farmers.

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18. Research for Tribal and Hill Regions

NORTH WEST HIMALAYAS

Breeder seed production: During the period under report, 16,138 tonnes breeder seed of 46 released varieties/inbreds of 17 crops were produced. A total of 13.121 tonnes breeder seeds were supplied to different seed producing agencies to further multiplication.

Quality seed production: Around 1,313 kg nucleus seed of 49 released varieties of 17 crops were also produced following standard methods of maintaining genetic purity. In addition to this, 655 kg Truthfully Labeled seed of 20 varieties of 13 crops were produced. Including the carry-over stock of TL seed; a total of around 402 kg TL seeds were supplied to different stakeholders.

Crop varieties released and notified

Variety	Area of adoption	Salient features
VLQPM Hybrid 45	North Western Hill Zone (Jammu & Kashmir, Himachal Pradesh and Uttarakhand Hills) and North Eastern Hill Region (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura)	Early maturing (90-95 days); at par yield (6,673 kg/ha) with the original normal corn hybrid VMH 45. Possesses mean tryptophan, lysine and protein of 0.66%, 2.90% and 8.72%, respectively. Moderate resistance against turcicum-leaf blight.
VL *Dhan* 69	Uttarakhand, Sikkim and J&K	Short bold grain, plant height of 95-105 cm, 125-130 days maturity and high panicles/m^2 (282). Average grain yield 4,255 kg/ha in medium hills (18.22% superiority over the best check VL *Dhan* 6). Unique decorticated grain colour (reddish brown). 79.9% hulling, 69.1% milling, 55.4% head rice recovery, intermediate ASV (5.0) and amylose content of 26.78%. Moderate resistance to leaf blast, neck blast, brown leaf spot and sheath-rot.

VL *Dhan* 69

Mature cobs of VLPQM Hybrid 45

CROP MANAGEMENT

Crop Production

Finger millet variety VL *Mandua* 379 was evaluated to four different nitrogen levels with three different split applications of urea under rainfed conditions. Among various nitrogen levels 60 kg N/ha recorded the maximum grain yield (3,332 kg/ha) which was at par with 80 kg N/ha (3,200 kg/ ha). The highest grain yield was recorded with three different splits (3,306 kg/ ha).

Bacterization of finger millet (VL *Mandua* 379) seed with PGP bacteria/consortia T10 (75% RDF + *Pesudomonas* + *Azotobacter*) recorded highest grain yield (2,065 kg/ha) followed by T16 {75% RDF (25% N BY FYM) + Consortium} (1,857 kg/ha) over un-inoculated control (T7) {RDF (75% RDF)} and (T12) {75% RDF (25% N BY FYM)} (1,694 and 1,532 kg/ ha, respectively) with 75% RDF and 75% RDF (25% N by FYM). Maximum HI was recorded by T10 (34.8) followed by T13 {(34.2) among all the treatments.

Varieties notified for Uttarakhand [State Varietal Release Committee (SVRC)]

Variety	Area of adoption	Salient features
VLQPM Hybrid 61	Uttarakhand Hills	Early maturing (85-90 days) hybrid. Average yield in the state coordinated trials 4,435 kg/ha. Moderate resistance against turcicum and maydis leaf blight.
VLQPM Hybrid 63	Uttarakhand Hills	Maturity, 90-95 days; average yield, 4,675 kg/ha. Possesses mean tryptophan, lysine and protein of 0.72%, 3.20% and 9.22%, respectively. Moderately resistant to turcicum and maydis leaf blight.
VL *Gehun* 2028	Timely-sown rainfed organic production conditions of Uttarakhand hills	Average yield, 22.70 q/ha. Highly resistant to yellow and brown rust diseases.
VL *Gehun* 3010	Irrigated, late-sown production conditions of Uttarakhand Plains	Average yield potential of 58.19 q/ha. Highly resistant to yellow and brown rust diseases.
VL *Dhan* 210	Organic conditions of Uttarakhand	Average grain yield of this variety under organic conditions was 2,157 kg/ha. Plant height, 90-110 cm. Resistance against leaf and neck blast (score 1-3), brown leaf spot (score 3-4), false smut (score 0-1), stem-borer and leaf folder (score 0-3) under natural condition. Better quality characteristics like high hulling (78%), milling (67%), HRR (58%) and amylose content (22.8%). Long slender grain kernel length (7.96 mm) and kernel breadth 2.38 mm and L/B ratio of 3.34.
VL *Dhan* 211	Rainfed upland spring sown organic conditions of Uttarakhand hills	Average yield potential of 2,088 kg/ha under organic conditions. Short bold grain and resistant to leaf and neck blast diseases. Plant heigh, 100-110 cm; very good and acceptable grain qualities, viz. 80% hulling; 69% milling; 60% HRR, 24.8% amylase content, 5.62 mm kernel length; 2.68 mm kernel breadth and L/B ratio of 2.09.

Mature cobs of VLPQM Hybrid 61

Mature cobs of VLPQM Hybrid 63

VL *Gehun* 2028

VL *Gehun* 3010

VL *Dhan* 210

VL *Dhan* 211

Variety released for Uttarakhand by State Varietal Trial (SVT)

Crop	Variety	Characteristics
Rice	VL *Dhan* 70	Irrigated, transplanted organic conditions, extra-long slender grain, grain yield 3,944 kg/ha. Resistant against leaf and neck blast, brown leaf spot.
Lentil	VL 150	Small seeded, yield 841 kg/ha. Possesses moderately resistance against wilt, rust, pod damage and aphids.
Field pea	VL 64	Yield 990 kg/ha. Moderately resistance against wilt and powdery mildew.

Crop Protection

Identification of indigenous entomopathogenic nematode and its biocontrol potential: Entomopathogenic nematodes (EPNs) are the potential biocontrol agents for the management of wide range of insect-pests. The soil samples collected from district Almora were baited with *Corcyra cephalonica* and observed regularly for their mortality. The results showed that *Heterorhabditis indica* isolate VLEPN01 was capable to cause 100% mortality in early instars of fall armyworm (*Spodoptera frugiperda*), white grub (*Holotrichia* spp.), bihar hairy caterpillar (*Spilosoma obliqua*) and tobacco caterpillar (*Spodoptera litura*) under *in-vitro* condition.

Social Science

- Survey of women farmers of mid hill regions was carried out and their workload and nutritional status along with dietary pattern was studied. The mean MDD-W for the sample was 4±1.03 which was suggestive of inadequate diets, which lacked variety.
- To meet the challenge of ameliorating occupational health of farm women by improving their diets and reducing drudgery, an Information-Education-Communication based strategy to provide the women farmers access to vegetable seeds and information on good nutrition and ergonomic practices to bring change in their behaviour was undertaken.
- After the intervention, 70% of women could attain desired Mean Diversity Score, i.e. above five which means these women were practising inclusion of food from five food groups in their meals, which was earlier achieved by 30% of women only. Improved dietary diversity has the potential to help improve nutrition outcomes in the area.
- Provision of seeds, technical backstopping, educational intervention through planned strategy increased the production of vegetables, improved accessibility to vegetables as per ICMR recommendations, and consumption of the micronutrient-rich vegetables. In the intervention sites, about 73% of families were growing more than 5 vegetables in their plots.

Evaluation of PGP consortium (PGP Consortium 5) on yield of different varieties of finger millet

- Household food insecurity access scale (HFIAS) was used and categorized households into four categories of food insecurity severity ranging from food secure to severely food insecure. More than half (53.85%) were secure, 30.77% were mildly unsecure and a few (15.38%) were moderately insecure households. Mildly and moderately secure households were deficient in variety and preferences of the type of food and a few showed anxiety about household food supply. Majority (73.08%) women were having low Dietary Diversity Scores (DDS) (Less than 5) with an average DDS of 4.23.
- Majority of the respondents (56.16%) belonged to the middle age group. About 29.55% of the respondents were educated up to high school. Majority of the respondents (61.08%) belonged to nuclear family, whereas 38.92% of them were from joint families. About 49.26% of the respondents had medium family size. Almost half of the respondents (52.22%) had accessibility to extension services.

NORTH EAST HIMALAYAS

Integrated farming system for sustainable livelihood of hill farming community: A total eight micro watersheds comprising Dairy-based land use, Mixed forestry, Silvi-pastoral land use, Agro-pastoral system, Agri-horti-silvi-pastoral, Silvi-horticultural system, Natural forest block and Timber-based land-use system were developed and evaluated on a long-term basis in Meghalaya. Among the land use systems, dairy-based farming system was evaluated on a micro watershed of 1.39 ha area including natural forest (0.45 ha), broom and guinea grass (0.94 ha), milch cows (3 nos.) along with their calves. The system has shown an annual net income of ₹ 1,09,328. In the agro-pastoral system (0.64 ha), the top portion of the water shed was utilized with a single crop, the middle portion with double cropping, and the bottom portion with triple cropping. Vertical farming was also included for proper utilization of the land and to maximize yield and income. The integration of crops and livestock resulted in maximum income (₹ 2,71,400.00) and employment generation (252 man-days excluding family labour). For jhum improvement, one agri-horti-silvi-pastoral system was developed in 1.58 ha covering agricultural crops, horticultural crops, silvi-pastoral crops and one milch cow. The system produced 6,846 kg of rice equivalent yield with a net return of Jay ₹ 62,961.

In Manipur, all total 7 sustainable IFS models were standardized under different agro-ecosystems at varying elevations ranging from 808-1723 m above msl. After the intervention, the cropping intensity was increased up to 180 to 300% compared to 100-120% in traditional farming system. The crop diversification was also

SUCCESS STORY

Mushroom Production: A Source of Income Generation

The challenge

Mr. Nandan Prasad, a 61-year-old Scheduled Caste (SC) farmer of village Uderkhani of district Bageshwar, is having the responsibility of seven members' joint family living below poverty line (BPL). His primary occupation is agriculture; however, previously he was also engaged in traditional occupation of copper smithy. He is having around 18-nali land (3,600 sq m), out of which 10 nali (2,000 sq m) is irrigated,. He along with his young son Mahendra Prasad has been growing various crops for their family survival. However, enhancement of income from small piece of land for seven-member family has always been a challenge.

The solution

ICAR–Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora along with its Krishi Vigyan Kendra, Kafligair (Bageshwar) selected Uderkhani village of Bageshwar district for implementation of its Scheduled Cast Sub-Plan (SCSP) Programme. During the visit of scientists in the village and interaction meetings with farmers, Mr Nandan Prasad and some other farmers showed interest for mushroom production. However, they were not having any experience or skill of this venture. It was a new venture in this village since nobody was involved in mushroom production. A training programme was organized by ICAR-VPKAS, Almora for the farmers of village Uderkhani at KVK (ICAR-VPKAS), Kafligair, Bageshwar under SCSP Programme. Demonstrations of button mushroom were also laid down at farmers' field.


Activities under SCSP Programme

The application

After getting training on mushroom production and demonstrations of button mushroom, Mr. Nandan Prasad started to take keen interest in mushroom production. He started this venture with 500 kg pasteurized compost in an abandoned room after proper cleaning and sanitation. He remained in touch with the experts and performed all the processes. The close monitoring, awareness, zeal to grow a new product of the area and sincerity led to produce a bumper crop of button mushroom and Mr. Nandan Prasad produced 100 kg saleable button mushroom. It was the first mushroom production in the area.

The impact

He sold his produce at an average price of ₹ 170 kg in the nearby market and earned ₹ 17,000 from a very short span of time. Thus, he could develop the belief among the fellow farmers about this new commodity of the area. Now, he has become the lead mushroom grower of the area and many other farmers are approaching him to know and adopt the mushroom farming. In the words of Mr Nandan Prasad, "Mushroom production is a profitable venture especially for the marginal farmers, it is safe from the two major threats of hill agriculture, viz. wild animals and weather vagaries."


Dr H S Gupta, Former DG, BISA; Dr J C Rana, National Coordinator, UN Environment GEF project and Country Representative, India Office of Alliance of Biodiversity International & CIAT, New Delhi; Dr Lakshmi Kant, Director, ICAR-VPKAS visiting the mushroom production room of Mr Nandan Prasad.

SUCCESS STORY

Escalating Horse Gram Production Through Improved Technologies for Livelihood Security Among Hill Farmers in Uttarakhand

The challenge

Horse gram is one of the major *kharif* pulse in North Western Himalayan hills particularly, in Uttarakhand. It plays an integral role in hill agriculture as well as provide livelihood and food security to the millions of rural inhabitants. Due to non-availability of quality seeds of improved varieties, improper crop management, poor agricultural mechanization and post-harvest processing, farmers of the region were not able to reap the potential benefits from its cultivation.

The solution

Improved high yielding cultivars of horse gram (VL *Gahat* 15 and VL *Gahat* 19) have appreciable yield potential of 800-1,000 q/ha as compared to local landraces along with resistance against wilt, anthracnose and other prevalent diseases. These varieties also have suitability for organic farming conditions. In addition to improved varieties, scientific crop management practices, farm mechanization implements and post-harvest processing methods offer an excellent solution for enhancing the profitability of farmers.

The application

High yielding varieties along with improved crop management practices were demonstrated in the different villages namely Mujholi, Bhat Gaon, Gallibaseura of Almora district, where horse gram is grown at large scale. Improved small tools were also introduced for ease in adopting the improved agricultural practices and preparation of value added products like tofu and milk were demonstrated to farmers for income generation.

Field of Horse gram with recommended package of practices.

The impact

Appreciable yield enhancement and profitability was realized through the adoption of improved varieties with recommended package of practices. With full package of practices, the crop yield improved significantly in horse gram by 30-35%, respectively than traditional crop cultivation practices. The income of farmers with the improved technologies was enhanced from ₹ 36,070- 66,270 per ha due to premium prices of horse gram in the market. The B:C ratio also improved from 0.66-1.21. Overall, from the cultivation of improved varieties farmers earned the benefit of ₹ 30,200/ha than traditional cultivars.

SUCCESS STORY

Microbial Stimulant for Shortening Mushroom Pinhead Initiation and Enhancing Yield

The challenge

Commercial mushroom production is based on a series of solid fermentation stages under controlled conditions in which bacteria and fungi have major roles in processing raw materials, minimizing fungal competitors and inducing fructification. A wide variety of interactions between bacteria and cultivated mushrooms have been described leading to both positive and negative outcomes for the fungus, depending on the bacterial isolate and the developmental stage of the fungus. The casing is the coverage material placed onto the substrate colonized by the host mycelium. Some of the most commonly cultivated species of mushrooms, i.e. *Agaricus bisporus* and *Macrocybe gigantea* require casing to fructify. The mycelium of these fungi secrete volatile organic compounds (VOCs) which act to suppress the initiation of fructification. Normally in *Macrocybe gigantea* and *Agaricus bisporus* primordial/pinhead initiation period is longer (~13-15 days) and yield of crop is low. Therefore, there is need to reduce the primordial initiation period and to enhance the yield of edible mushroom.

The solution

Casing application of *Pseudomonas* sp. NARs9 enhanced *Macrocybe gigantea* fruiting body yield by 116.1% and 104.4% in comparison to untreated control during 2018 and 2019, respectively. The pinhead initiation period was also reduced (7.5 and 7.0 days) in comparison to control (13.5 and 12.0 days). During *rabi* 2018-19 and 2019-20, casing application of *Pseudomonas* sp. NARs9 resulted in 38.3% and 43.0% higher yield of *Agaricus bisporus* in comparison to untreated control, respectively. The pinhead initiation period was also reduced (8.7 and 8.0 days) in comparison to control (11.0 and 11.3 days), respectively *Macrocybe gigantea* fruiting body

The application

We found shortening of primodial initiation period in edible mushroom by adding a microbial stimulant *Pseudomonas* sp. NARs9 strain, which results in enhancement in yield of edible mushrooms. The liquid formulation of microbial stimulant/enhancer was found to shorten pinhead initiation period in edible mushrooms, *Macrocybe gigantea* and *Agaricus bisporus* with enhanced yield. Yield enhancement in edible mushroom, *Macrocybe gigantea* (>75%) and white button mushroom, *Agaricus bisporus* (>30%) in comparison to uninoculated control was recorded. The primordial initiation duration was shortened by 6 and 3 days in *M. gigantea* and *A. bisporus*, respectively, as compared to uninoculated control.

The impact

The promising *Pseudomonas* sp. NARs9 was inoculated at farmer's field. The bioagent was applied in 47 bags (8 kg compost) of button mushroom at the time of casing soil application, whereas 49 bags were kept uninoculated. The total yield obtained was 96.5 kg (25.7% biological efficiency, BE) against 66.5 kg of uninoculated control (16.96% BE). The per cent increase in yield and BE were 45.1% and 8.7%, respectively.

Button mushroom crop at farmers place

When this strain was applied in casing soil of *Macrocybe gigantea* mushroom bags at farmer's field, average yield obtained was 850 g per bag (85.0% BE) which was 54.5% higher than that of untreated control.

increased from 5.71-16.67 to 10-33.34 nos. of crops/ha/year. The farming intensity has also been increased 300 to 500%, as compared to 150-200% in traditional farming system. The models ensured generation of 409 to 570 days of employment as compared to 101-120 days in traditional farming system. Similarly, the employment productivity was also increased from 14-48.50 to 91.25-135.71 man-days/ha/year. Among the models, one high value IFS model comprising horticultural crops (1.25 ha) + field crops (1 ha) + fish pond (1 ha) + circular carp hatchery (1 unit with 100 brooders) + piggery (3 nos.) + poultry (300 nos.) + jalkund (2 units) + agro-shade net house (2 nos.) + bee box (3 units) + vermicomposting (3 units) + fruit processing (1 unit) recorded a B:C ratio of 6.49.

In Nagaland, four diverse IFS models were

developed. Of these, Model 1 [Horticulture (2,939 sq. m) + Agriculture (1,475 sq. m) + Fishery (1,062 sq. m) + Piggery (100 sq.m) + Vermicompost (6 sq. m)] and Model 2 [Agriculture (2,116 sq. m) + Horticulture (1,611 sq.m) + fishery (500 sq. m) + Goatery (30 sq. m) + Vermicompost (6 sq. m) recorded the highest net income of ₹ 2,64,854 and ₹ 2,47,389 per ha per year. Both the models generated an employment of 360 man-days per year.

In Tripura, two Farming Systems, viz. Integrated Seed based Farming System (ISFS-0.85 ha) and Integrated Intensive Farming System (IIFS-0.70 ha) were established. Apart from crop production and dairy unit, both the systems included fodder grasses on the terrace risers and fences, compost pits, ponds for fish farming and life saving irrigation, plantation crops like arecanut, mango, banana, litchi, papaya, coconuts, etc. The total energy input and output in ISFS were 2,49,416.2 MJ and 15,40,304.5 MJ, respectively. The energy input and output for IIFS were 1,34,257.57 MJ and 4,51,878.73 MJ, thus energy-use efficiency for ISFS and IIFS was 6.1 and 3.3, respectively. The net return received was ₹ 2,49,634 and ₹ 1,49,257 and B:C ratio was 5.9 and 3.9 under ISFS and IIFS, respectively. Employment generated for ISFS and IIFS was 345 and 325 days, respectively. The rice-equivalent yield (REY) for the whole ISFS was 16.33 tonnes/ha and for IIFS it was 10.86 t/ha.

Integrated Organic Farming System for income and employment enhancement: Integrated Organic Farming System (IOFS) models were established at Tripura and Meghalaya. The Tripura model gave a net return of about ₹ 73,990. and employment of 67 days which is quite high compared to existing farming systems. About 70% of the nutrient requirement of the model was met from nutrient recycling within the model. The Meghalaya model recorded a total net return of ₹ 83,360 per year which is much higher than the region's farmer common practices of rice monocropping or improved practice of the rice-vegetables cropping system. Approximately 96% of the total N requirement, 87% of the total P_2O_5 requirement and 99% of the total K_2O requirement could be met within this model thus making it a self-sustainable one.

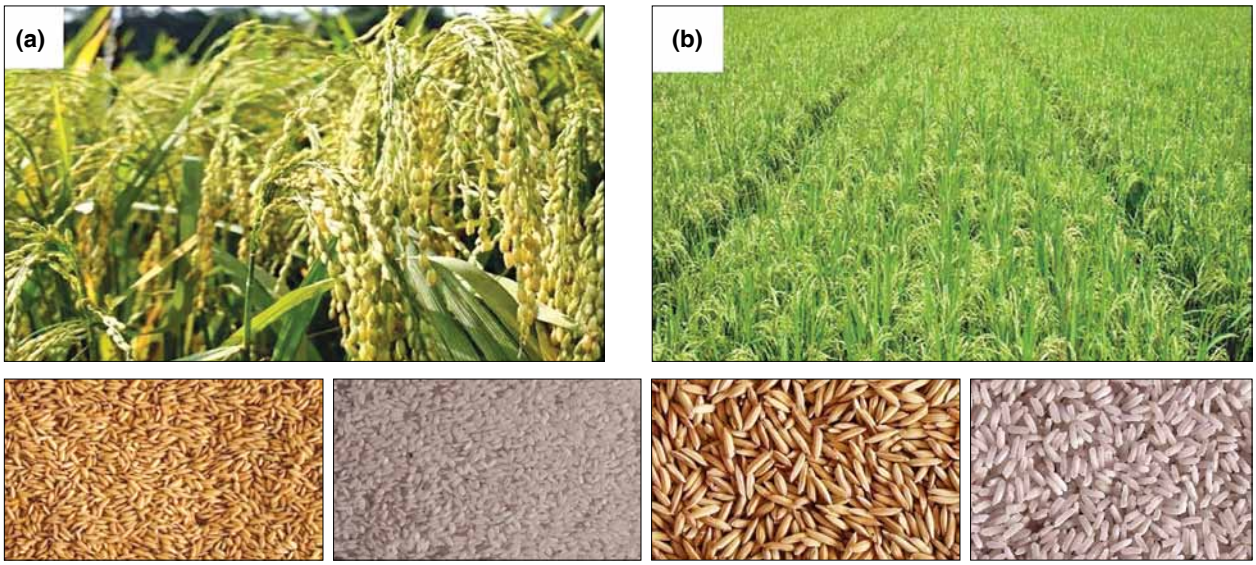
Ten high yielding stress tolerant crop varieties released: Two drought tolerant rice varieties, namely ICAR-NEH NICRA Hill Rice 2022-2 for cultivation in the Upland Hills of Himachal Pradesh and Manipur while ICAR NEH NICRA-Boro Dhan 1 for Boro cultivation in Tripura, Assam and West Bengal, developed by ICAR Research Complex for NEH Region, Tripura Centre, were released and notified by VIC-CVRC for central release. ICAR-NEH NICRA Hill Rice 2022-2 has a yield advantage of 19.87%, 27.07% and 23.03%, compared to National Control (NC), Regional Control (RC) and Local Control (LC), respectively. ICAR NEH NICRA-Boro Dhan 1's yield advantage is 20.8 to 50.98%.

Besides, one guava variety Megha Magenta, developed by ICAR Research Complex for NEH Region, was recommended for release by VIC-CVRC. Fruits are sweet in taste, high TSS (9.9–10.4%), low acid (0.50–0. 0.63%) with fairly good in ascorbic acid content (181.14–205.64 mg/100 g). The attractive red pulp colour makes it very suitable for processing.

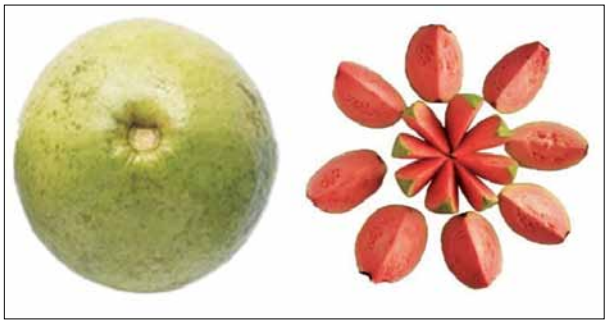
In addition, eight high yielding varieties of crops including three rice varieties namely RC Maniphou-14, RC Maniphou-15 and RC Maniphou-16; two

General view of farming system developed in different north-eastern states

IOFS models developed in Tripura and Meghalaya



Two rice varieties namely (a) ICAR-NEH NICRA Hill Rice 2022-2 and (b) ICAR NEH NICRA-Boro Dhan 1 developed by ICAR-RC-NEHR, Tripura Centre



Guava variety Megha Magenta

Ceremonial release of crop varieties by Hon'ble Chief Minister of Manipur

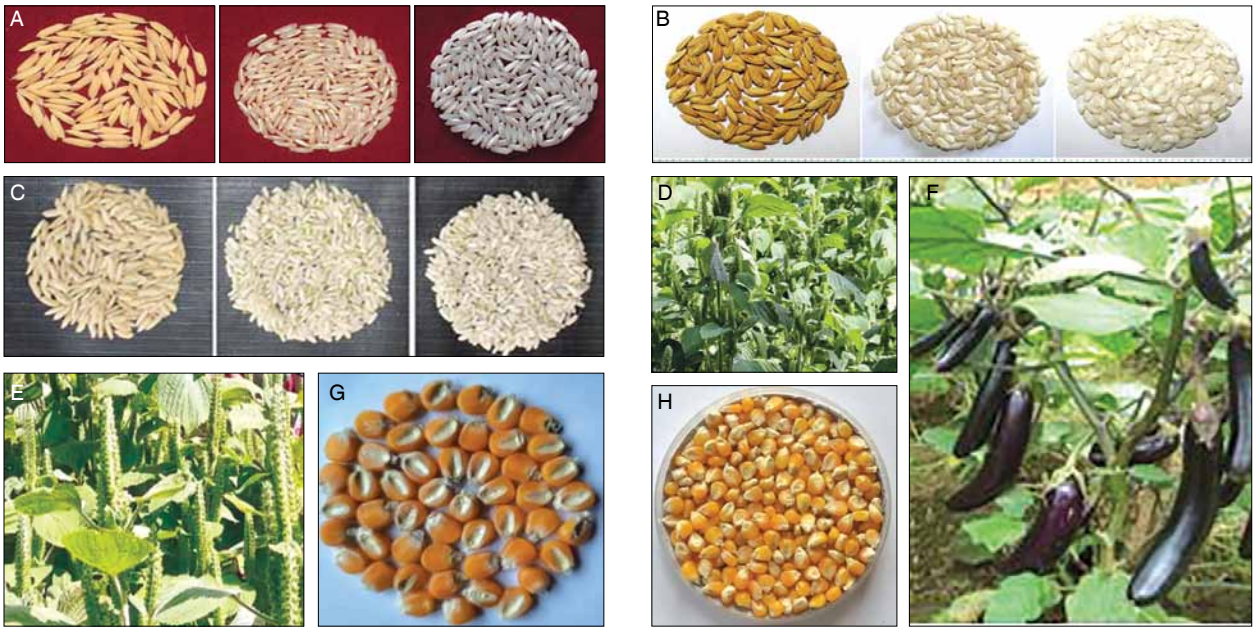
perilla varieties namely RC Manithoiding-1 and RC Manithoiding-2; one brinjal variety RC Manikhamen-1 and two maize varieties RC Manichujak-1 and RC Manichujak-2 developed by ICAR Research Complex for NEH Region, Manipur Centre were recommended by SVRC, Manipur and ceremonially released by Hon'ble Chief Minister of Manipur. Three rice varieties have higher yields potential of 7-8 t/ha with soft cooking quality and recommended for main rainy (*kharif*) season under transplanted conditions of the state. Perilla varieties RC Manithoiding-1 and -2 which were the first high yielding perilla varieties released so far. The varieties are rich in oil content (~45% and 41% oil). Brinjal variety RC Mankahmen-1 has potential yield is 340 q/ha and high tolerance to bacterial wilt. Maize variety RC Manichujak-1 is a flint corn variety and RC Manichujak-2 is a popcorn variety and both maize varieties are recommended for rainy (*kharif*) season in the state.

ISLAND AND COASTAL REGION

Rice-based Integrated Farming System model for west coast region: Rice-based farming system model (crop-dairy-fishery) for 0.5 ha lowland situations of the west coast region was developed. Different enterprises were: rice followed by cowpea/green gram/vegetables/ baby corn/sweet corn - 0.4 ha, forage grown on bunds (Hybrid Napier - 0.032 ha), dairy (24 m^2 - two crossbred

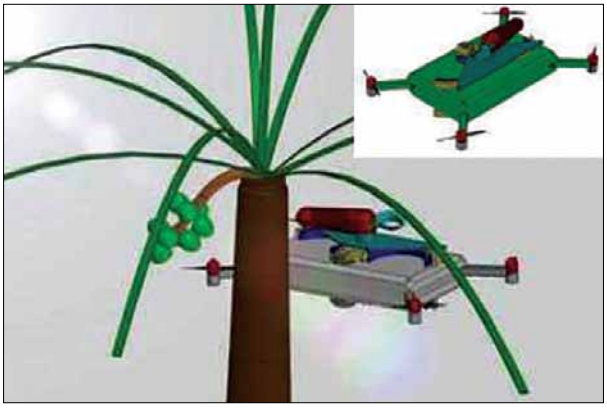
cows, one female calf- 24 m^2), FYM unit (10 m^2) and kitchen garden (80 m^2). The net return from the 0.5 ha model was ₹1.39 lakhs and the highest contribution was from crops (56%), followed by dairy (32%) and fishery (12%)

Fly Cocobot (A drone-based coconut harvester– a nationally awarded concept): Timely harvesting of coconut is a big problem of farmers due to poor



Eight crop varieties, (A) Rice variety RC Maniphou 14, (B) Rice variety RC Maniphou 15, (C) Rice variety RC Maniphou 16, (D) Perilla variety RC Manithoiding-1, (E) Perilla Variety RC Manithoiding-2, (F) Brinjal variety RC Manikhamen-1, (G) Flint corn synthetic variety RC-Manichujak-1, (H) Pop corn variety RC Manichujak-2 Developed by ICAR-RC-NEHR, Manipur Centre.

availability of *"Padelis"* (traditional coconut harvesters) as there are risks involved and practical difficulty in climbing in coconut-blackpepper system, a most common practice in the entire coastal region. Fly Cocobot is a drone-based remotely controlled unmanned gender-friendly coconut harvesting and crown-clearing



Fly Cocobet

machine for safe harvesting of coconuts. It flies to the top of the palm, gets attached to the trunk with grabbing arms, cutting arm then opens up for cutting the desired bunch decided through video displayed on screen of the remote module. Pragmatic uniqueness of this device lies in its suitability for using in mixed cropping plantation of coconut and blackpepper thereby leading for higher returns. The machine is conceptualized, through Joint efforts by ICAR-CCARI, Old Goa and Goa University, to have operational efficiency of 12-15 palms/hr.

TRIBAL SUB PLAN (TSP): A total 22 numbers of pig health and awareness camp cum input distribution was conducted during 2021. Total 3,42,401 kg of pig feed was distributed among 2,612 tribal beneficiaries of

different villages of Kamrup, Nalbari, Baksa, udalguri and Goalpara district of Assam. Four trainings were organised for benefitting 68 tribal youths and farmers.

SCHEDULED CASTE SUB PLAN (SCSP): Scheduled caste sub plan activities are being implemented in 12 villages of five districts of Assam Kamrup, Nalbari, Morigaon, Dhemaji and Barpeta covering around 611 beneficiaries. In order to encourage SC farmers for scientific pig production farmers field day has been conducted in different villages of Assam and distributed good quality pig breeds (84 nos.) and concentrate pig feed (524 q).

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19.
IP, Organization and Management

Department of Agricultural Research and Education

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture, Government of India in December 1973 to coordinate and promote agricultural research and education in the country. DARE provides necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research in areas including crop science, horticulture science, natural resource management, agricultural engineering, animal science, fisheries science, agricultural education and agricultural extension in the entire country. With 113 ICAR institutions and 74 agricultural universities spread across the country, this is one of the largest national agricultural research systems in the world. Apart from ICAR, the Department of Agricultural Research and Education has other autonomous bodies, viz. Agricultural Scientists Recruitment Board, the Central Agricultural Universities (Caus) at Imphal (Manipur), Jhansi (Uttar Pradesh), and Pusa (Bihar); Agrlnnovate India Limited, Delhi, under its administrative control. The Agrlnnovate India Limited (incorporated on 19 October 2011) aims to work on the strengths of DARE and ICAR and promotes, and spreads its research and development outcomes. The Agrlnnovate India Limited is an extended independent commercial outfit, which is expected to capitalize on the vast network of the ICAR institutes where the researchers are engaged in their mission to innovate and harness science to provide citizens access to food, nutrition, livelihood and income security.

Indian Council of Agricultural Research

The Indian Council of Agricultural Research is an autonomous organization under the Department of Agricultural Research and Education, 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, with support facilities in Krishi Anusandhan Bhawan 1 and 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, Department of Agriculture Research and Education, Government of India. 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 headed by the community Director General, who is also the Secretary, DARE is the chief executive and decision making authority of the ICAR. The Governing Body consists of eminent agricultural scientists, educationist, public representatives and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and Publications Committee. In scientific matters, the Director General is assisted by 8 Deputy Directors General, one each in (*i*) Crop Science, (*ii*) Horticulture Science, (*iii*) Natural Resource Management, (*iv*) Animal Science, (*v*) Agricultural Engineering, (*vi*) Fisheries Science, (*vii*) Agricultural Education, and (*viii*) Agricultural Extension, who are also assisted by Assistant Directors General, and are the Heads of their Subject Matter Division (SMDs) for the entire country. SMDs are responsible for extending all technical and financial guidance and support to the research Institutes, National Research Centres and the Project Directorates within their respective Divisions. In addition, Assistant Directors General of National Agricultural Science Fund (NASF), Coordination, Plan Implementation and Monitoring, Intellectual Relations and Human Resource Management also assist the Director General in their respective job roles. The research set up of the ICAR include 113

Institutions which consist of 72 Research Institutes, 6 National Bureaux, 23 Project Directorates and Agricultural Technology Application Research Institutes, 12 National Research Centres, 82 All India Coordinated Research Projects + Network Research Projects. The Directorate of Knowledge Management in Agriculture (DKMA) functions as communication arm of the ICAR responsible for delivery of information/knowledge generated by the network of the ICAR and its institutions; and addresses mandate of ICAR through Publications, Information, ICT, Public Relations Unit and CeRA. The ICAR promotes research, education and frontline extension activities in 74 Agricultural Universities, which include 63 State Agricultural Universities, 4 Deemed Universities, 3 Central Agricultural Universities, and 4 Central Universities with agricultural faculty by giving financial assistance in different forms.

Indian Agriculture and rural life have undergone tremendous transformation since independence. Agricultural development is an integral part of overall economic growth and was the main source of national income and occupation at the time of Independence. It contributed about 50% to India's national income and around 72% of total working population was engaged in agriculture at that time. Although the contribution of agriculture to national GDP is decreasing over the years, it is important that the growth of other sectors and overall economy depends on the performance of agriculture to a considerable extent. Because of these reasons, agriculture continues to be dominant sector in the Indian Economy. The post-Independence journey of Indian Agriculture has been quite impressive despite several limiting factors such as uncertainties of weather, declining soil health, increasing atmospheric temperature and emergence of more virulent pests and pathogens. Technological advancements in agriculture have been influential in driving changes in the farm sector. Although the amount of land and labour used in farming declined, the total farm output increased more than 5 times between 1950-51 and 2020. Similarly, the yield (kg/ha) has increased about four times during the same period.

The digital revolution has opened new windows for Indian farmers. Technologies like precision agriculture, e-extension, drone-led operations, smart warehousing and transport optimization, real-time yield estimation and price information, credit and insurance management and e-marketing have proven their applicability in making agriculture predictable and profitable.

ADMINISTRATION

Filling up of vacant posts

During the year, following posts were filled up under the promotion quota: 6 Joint Secretary/Joint Director (Admin), 3 Joint Secretary (Finance)/ Senior Comptroller, 8 Director/CAO (Senior Grade), 4 Director (F)/Comptroller, 1 Director (Official Language), 15 Deputy Secretary/CAO, 1 Deputy Director (Finance), 3 Joint Director (OL), 2 Senior Principal Private Secretary, 5 Under Secretary, 1 Senior Administrative Officer, 5 Senior Finance and Account Officer, 48 Principal Private secretary, 6 Deputy Director (OL), 43 Administrative Officer, 17 Finance and Accounts Officer, 13 Section Officer, 11 Private Secretary and 22 Assistants at ICAR Headquarters.

Financial Up-gradation granted under MACP scheme

During the year, 10 eligible officers and Staff of ICAR were granted the benefits of financial up-gradation at ICAR Headquarters under the Modified Assured Career Progression scheme in accordance with the Government of India (DoPT) instructions in this regard.

Finance

The Revised Estimates in respect of DARE/ ICAR for 2021-22 was ₹8,513.62 crores. An internal resources of ₹352.20 crores (including interest on Loans and Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2021-22. The total allocation Budget Estimates for 2022-23 is ₹8,513.62 crores.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT

Innovation Management

Patents: During the period under report 78 new Patent Applications were filed pertaining to varied sectors of agriculture. Thus the cumulative figure has now risen to 1,455 applications. Indian Patent Office (IPO) had published ICAR's 37 patent applications in this period. Further, the IPO had granted 47 patent applications, taking ICAR's cumulative number of granted patents to 455. In this process, 31 ICAR institutes were involved to protect their innovations.

Important Patent Applications Processed at Indian Patent Office for different ICAR Institutes

Name of Institute	Name of Innovation/Technology/Products
CARI, Izatnagar	Cari Protirich Biscuits
CCARI, Goa	Method and System for Detection of Stem and Root Borer Infestation
CIAE, Bhopal	Orifice Based Hydrodynamic Cavitation System for Shelf Stable Sugarcane Juice and Process Thereof
CIBA, Chennai	Anti-Microbial Peptide From *Penaeus Vannamei* for The Treatment of Vibriosis
CIFE, Mumbai	DNA Construct Expressing Antisense RNA and formulation Made Therefrom
CIFE, Mumbai	Recombinant Gene Promoter
CIFT, Cochin	Method for Determining the Quality of a Packaged Fish
CIRCOT, Mumbai	Air Cooling and Circulating System for Improving Thermal Comfort of Impermeable Apparels
CMFRI, Cochin	Micro Bubble Diffusing Aeration Apparatus in Mariculture Pond
CSWRI, Avikanagar	Coarse Wool Made Sapling Bag
CSWRI, Avikanagar	Engineered Recombinant Kisspeptin Protein and Method of Production Thereof
CTCRI, Kerala	Power Operated Size Based Chinese Potato Grader
DFMD, Bhubaneswar	Thermotolerant Foot-And-Mouth Virus(FMDV) Serotype O IND R2/1975 with Enhanced Immunogenicity in Cattle
DMAPR, Anand	Extracts and Purified Phytochemicals from *Garcinia* Species Exhibiting Cytotoxicity against Human Colon Cancer
DPR, Hyderabad	Composite Feed Additive For Improved Performance, Immunity, and Healthier Gut Microbiome
IARI, New Delhi	Compost Turner Cum Mixer Device and a Method Thereof
IGFRI, Jhansi	Process for Isolation of Non-Steroidal, Anti-Inflammatory Compound from *Anogeissus pendula*
IIMR, Hyderabad	Novel Process for Formulating a Low-Cost Scarabid Specific Bt for Management of White Grub *Holotrichia serrata*
IIMR, Ludhiana	Molecular Differentiation Assay for Categorizing Samples as Normal or QPM
IINRG, Ranchi	Microwave Assisted Improved Process for Extraction of Aleuritic Acid from Lac
IIRR, Hyderabad	Anhydrous Natural Pain Relief Composition for Topical Application
IISR, Calicut	Granular Lime Formulation and a Process for its Preparation
IISR, Lucknow	Sugarcane Trash Manager-Cum-Stubble
IISS, Bhopal	Microbial Consortia For Accelerated Decomposition Of Organic Waste, And Method Of Decomposition
IVRI, Izatnagar	Chicken Embryo Fibroblast Cell Culture Based Live Attenuated Duck Plague Vaccine (Strain: Dpvac/IVRI-19)
NIANP, Bengaluru	Device for Collection and Measurement of Enteric Methane Emission in Ruminants
NIASM, Baramati	Process for The Development of Nanoscaled Metallic Formulations for Aquaculture
NIPB, New Delhi	Rice Blast Disease Resistance Governing Gene Containing A Von Willebrand Factor Domain.
NIRJAFT, Kolkata	Microbial Keratin Solubilization from Animal Hair – A Method Thereof
NIRJAFT, Kolkata	Process for Manufacture of Antioxidant Rich Jute Leaf Suitable for Ready to Use Jute Leaf Drink
NRC Equines, Hisar	Method for Encapsulation of Bacteriophage Cocktail Against *Salmonella* Sp for Oral Delivery in Poultry.
NRC Grapes, Pune	Process for Preparing Activated Carbon Nanoparticle and its Application Thereof
NRC PIG, GHUATI	Process for Preparation of a Spray for Surface Decontamination of Pork Carcasses Using Fermented Bamboo Shoot Extract and Spray Thereof
NRRI, Cuttack	Efficient Portable Insect Collector with Automated Counter

To protect the Plant Varieties, 31 varieties (19 extant and 12 new varieties) were filed at Plant Varieties and Farmers' Rights Authority (PPV&FRA). Twenty-one plant varieties (19 extant and two new varieties) were registered during this period. The cumulative of registered plant varieties is 1381. Intellectual Property Rights (IPRs) of other categories such as copyright, trademark and designs were also filed by ICAR institutes.

Other IPR Tools Used for Innovation Management at ICAR Institutes

IPR Tools	Copyright	Trademark	Designs
Application Filed (Cumulative)	159 (460)	29 (218)	14 (87)
Institute Involved	25	14	6
Type/Category	Computer Software; Literary/Dramatic	Word; Device	Prototypes

Capacity Building Activities

To create awareness in the subject area of innovation management and technology transfer,and plant protection and farmers rights act, different ICAR institutes have organized various capacity building programmes at institute/ zonal/national level. In this process, 60 ICAR institutes organized 197 awareness generation programs/interface/ product-specific meets/workshops/seminars, where in 14035 scientists/researchers/business professionals/farmers/ social workers were benefited.

Glimpse of Technology Commercialization Activities at Institute Technology Management Units

Technology Transfer/Commercialization

The period also witnessed increased involvement of ICAR institutes in licensing technologies to different public and private sectors organizations. The mode of partnerships largely had been through formal Licensing Agreements. Accordingly, this year, 661 such license agreements were signed with 452organizations for 379 technologies by 55 institutes.Out of these 661 licenses, 227 were IP protected.

Professional Services: Eighteen ICAR institutions in different Subject Matter Divisions have entered into 80 agreements for consultancy/contract research and services with 75 public and/or private organizations.

Agri-business Incubation Centers

Agri-Business Incubation (ABI) Centers at 50 institutes facilitate entrepreneurs/start-ups. In the current year, these centers facilitated 449 entrepreneurs/startup by providing incubation space, know-how/technology, training, and validation of their products/ideas for converting in a business enterprise. After completing their incubation activities, 146 entrepreneurs graduated to start their own businesses.

Some of the important initiatives at different ABICs are as follows:

ICAR-CIBA, Chennai: To provide farm level diagnostic services, ABIC-CIBA has promoted Illume Gene India LLP., Bangalore, which is providing affordable disease diagnostic services to the shrimp farmers.

ICAR-CCRI, Nagpur: Ashok Agro, a Nagpur based start-up company, incubated at CCRI center with the support of Acid *Lime Nutri Jelly* technology. Ashok Agro launched this in the market as a business enterprise in the brand name of ***"Richer Land".***

ICAR-CIFT, Cochin: This centre developed a novel online fish auction platform, e-trading platforms for digital transformation of fisheries supply chain and launched e-auction and retailer portals for digital transformation of national fisheries supply chain.

ICAR-CPCRI, Kasaragod: A unique centre of the country for planation based products, organized Rural India Business Conclave; and Certified Agritech Start-up Professional (CAgtSP) Programme in collaboration with Kerala Startup Mission and Kerala Agricultural University.

ICAR-DMAPR, Anand: This Center which was recognized by Hon'ble Prime Minister in his Mann Ki Baat, has organized a series of 28 online Agri-Tech Entrepreneurship Development Program (AgritechEDP) in collaboration with Rural Development Foundation, Anand.

ICAR-NINFET, Kolkata: Centre's Start-up Smt. Chitra Saha, proprietor of Piyali Handicrafts, Kolkata has

SUCCESS STORY

Nutrihub

Millet based Agri-Business Incubation Centre at ICAR-Indian Institute of Millets Research, Hyderabad, which is working in the area of food processing, product designing, value chain creation, entrepreneurship and start-up development activities. Centre has supported 18 young entrepreneurs to register their enterprise as registered companies at Ministry of Corporation Affairs (MCA), who have engaged 272 employees on job. Nutrihub has also signed 18 agreements for new incubatees in the reported period, and organized 15 start-up ignition programme for emerging business opportunities in processing of millets, where 398 new entrepreneurs/start-ups got benefitted. This centre is equipped with 14 technical, and seven business mentors; and three investors on its board. Three of its start-ups, viz. Urban Monk Pvt Ltd (First Best Start Up) and Sakala Nutrition Pvt, Ltd (Best Start Up) won the award in FICCI Agri Start-up Summit for Nurturing Agri Innovations; and Millenova Pvt Ltd has won the best women entrepreneur award in Womennovator Global Summit. Centre has developed seven millet-based value-added technologies in the form of Ready to Cook and Ready to Eat food. To showcase its achievements Nutri-Hub participated in EXPO-2020, Dubai; and Bio Tech Start-up Expo 202; and also organized National Nutri-Cereal Convention (NNCC); and Millet Roadshow which was inaugurated by the Hon'ble Minister of state for agriculture & Farmers Welfare, Sushri Shobha Karndlaje. The continuous efforts of Nutrihub has been awarded Best Government Institute Award for IIMR's Nutrihub in Agri Business Summit and Agri Awards (ABSA). Institute is playing the key role in the International Year of Millets 2023.

received the Award "Outstanding Women Entrepreneur Award" for her excellent performance in the business in Natural Environment Friendly Product Specially Jute Diversified Product Sector since last five years.

To create an in-house business environment 213 Agri-business Development/Awareness Programmes were organized at ABICs, with 413 technology mentoring sessions. The strength of these ABICs lies in their mentoring capabilities, where 366 mentors on board as technology/business mentors.

Progressive Use of Hindi

Various useful programmes for public utility and farmers were organized by the institutions of the Council in Hindi and Regional Languages. All activities including agriculture extension related to KVKs located in Hindi speaking areas were also performed in Hindi and Regional Languages. Various publications on different subjects like Agricultural Sciences, Animal and Fishery Sciences and Horticultural Science were brought out in Hindi and Regional Languages by the Council and its institutes from time to time. With a view to provide knowledge of various technologies on agriculture and wider publicity thereof, monthly magazines like *Kheti* and *Phal-Phool* were published regularly. In-house journal of ICAR Headquarters *Rajbhasha Aalok* was published regularly. This magazine includes articles on scientific subjects and government schemes in simple Hindi besides reports of various programmes being organized by the Council and its institutes from time to time. The edition of the magazine for 2021 was released on 16 July 2022 through video conferencing by Hon'ble Union Minister of Agriculture and Farmers Welfare on the occasion of the Foundation Day of the Council. Total number of notified subordinate offices of the Council under Rule 10(4) of Official Languages Rules 1976 has increased up to 144.

During the period under report, 4 meetings of Official Language Implementation Committee were conducted on 20 December 2021; 30 March 2022; 29 June 2022; and 16 September 2022 respectively. In most of the ICAR Institutes/Centers, Official Language Implementation Committees (OLIC) have been constituted and meetings thereof were conducted regularly. Minutes of these committee meetings received at Headquarters were reviewed regularly and appropriate suggestions were given to the concerned institutes for taking remedial measures. The quarterly progress reports of ICAR-Headquarters are being sent on-line to the Delhi situated Regional Implementation Office, Department of Official Language, Government of India. The quarterly progress reports received from various Institutes are being reviewed and suggestions are given to them for effective implementation of OL policy. ICAR is participating in TOLIC's meetings regularly.

First Hindi workshop in ICAR Headquarters was organized on 14 December 2021 for Under Secretaries on "Use of Simple Hindi in day-to-day official work through E-tools". The second Hindi workshop was organized on 28 February 2022 for

the officers of technical category. The third Hindi workshop was organized with the collaboration of Directorate of Weed Research, Jabalpur on 7-8 March 2022 on the subject "Azadi Ka Amrit Mohotsav banam Rajbhasha Hindi" wherein Hindi officers including 55 personnel working in the subordinate Institutes of the Council located in western and central India had participated. The fourth Hindi workshop was organized on 24 June 2022 for Section Officers on the subject "Constitution of India and Constitutional status of Official Language Hindi" and filling up the quarterly progress report of Hindi in prescribed manner. The fifth Hindi workshop was organized on 24-25 August, 2022 at Barrackpore with the collaboration of Central Research Institute for Jute and Allied Fibers, Barrackpore on the subject "75 Years of Independence and Development of Official Language Hindi". In this, Hindi officers and officers associated with Hindi working in more than 100 institutions across the country had participated.

As usual, during this year also, Rajbhasha week/fortnight/month was organized at Council's Headquarters and its institutes. At Council headquarters, various Rajbhasha Competitions were conducted during "Rajbhasha Ullas Pakhwara". "Rajbhasha Ullas Pakhwara" was organized at Council's Headquarters from 16 September 2022 to 29 September 2022. On this occasion, the inspiring messages of Hon'ble Union and State Ministers for Agriculture and Farmers Welfare were issued. The Director General, ICAR also issued an appeal thereby urging all officers/employees to do their maximum official work in Hindi.

		Award
I	**Large Institutes**	First Prize
	National Dairy Research Institute, Karnal	
	ICAR – Indian Animal Husbandry Research Institute, Izatnagar, Uttar Pradesh	Second Prize
II	**Institutes/Centers of 'A' and 'B' Region**	
	ICAR – Directorate of Weed Research, Jabalpur	First Prize
	ICAR – Directorate of Mushroom Research, Solan	Second Prize
III	**Institutes of 'C' Region**	
	ICAR – Central Research Institute of Dry land Agriculture, Hyderabad	First Prize
	ICAR – Central Research Institute for Jute and Allied Fibers, Barrackpore, Kolkata	Second Prize

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 2021-22. Three more award schemes were being implemented by the Council at its own level; which are as follows:

Rajarshi Tandon Rajbhasha Purskar Yojana: Under this scheme, Institutes falling under 'A', 'B' and 'C' linguistic regions are awarded region-wise in different categories for excellent implementation of official language policy. During 2020-21, the following Institutes were awarded for doing their maximum work in Hindi.

Ganesh Shankar Vidyarthi Hindi Patrika Purskar Yojana: This scheme is applicable for the Official Language Magazines being published by various Institutes. Under this Scheme, awards are given away for best magazines in two categories, i.e. one is for the institutes located in 'A' and 'B' regions and other one is for the institutes located in 'C' region.

Dr. Rajendra Prasad Puraskar Yojana: Dr. Rajendra Prasad Puraskar Yojna is being implemented for encouraging to write books originally in Hindi. For 2021-22, following books, of (received the award) *Green House Khati: Utpadan ewam Sanrakshan* and *Pasudhan ewam Kukkut Utpadan Main Jaiv Suraksha.*

In accordance with the instructions/orders of Department of Official Language, Ministry of Home Affairs, a total of 38 Institutes were inspected for assessing the progress of Hindi during the period under report and suggestions were given to rectify the shortcomings observed during the inspection. This also includes inspections of Parliamentary Committee on Official Language. Besides, all materials to be presented in the Parliament, works

Magazines of the following Institutes were awarded

Selected magazine	Name of the Institutes	Award
(For 'A' & 'B' region)		
Ikshu	Indian Sugarcane Research Institute, Lucknow	First
Him Jyoti	Cold water Fisheries Research Institute, Bhimtal	Second
Shalihotra Darshan	Indian Veterinary Research Institute, Izatnagar	Third (Joint Award)
Tran Sandesh	Directorate of Weed Research, Jabalpur	
Sufalam	National Institute of Abiotic stresses Management, Baramati Maharashtra	Incentive Award
(For 'C' Region)		
Resha Kiran	Central Jute and Allied Fibre Research Institute, Kolkata	First
Jal Tarang	Central Institute of Brackish Aquaculture Research, Chennai	Second
Devanjali	National Institute of Natural Fiber Engineering and Technology, Kolkata	Third (Joint Award)
Ganna Prakesh	Sugarcane Breeding Institute, Coimbatore	

related to annual action report, review of grants-in demand, governing body, Standing finance committee, Parliamentary Committee of Ministry of Agriculture, including annual general body meetings of ICAR Society, all proceedings of these meetings were prepared bilingually, i.e. Hindi and English. Hon'ble Agriculture Minister and other Senior Officers delivered their addresses in Hindi. Their speeches/messages were originally drafted in Hindi in the Council.

TECHNICAL COORDINATION

The mandate of Technical Coordination Division includes preparation of monthly Cabinet Summary for Cabinet Secretary; Organizing meetings of 'Standing Committee' for grant of financial assistance to scientific societies and Academic Institutions; providing Financial Assistance to Scientific Societies for organizing seminars/symposiums/conferences and publication of Journals; collaborations of ICAR Institutes with industry; organizing Director's conference/ preparation of ATR and Agenda items; coordinating and organization of the ICAR Regional Committee Meetings; preparing draft invitation letters for VIPs; Collaboration with Department of Science and Technology, Bureau of Indian Standards etc.; of deal with the references received from Prime Minister's Office, President Secretariat etc.; laying of ICAR Annual Report, Annual Accounts and Audited Report of ICAR in both the Houses of Parliament; Preparation of reply of parliament Questions of inter-divisional nature and Coordination, Nodal Point for e-Samiksha portal for DARE/ICAR and releasing funds for Swachchta Action Plan (SAP); compilation and uploading of its Quarterly Reports on SAP Portal as well as work related to coordinating in nature received time to time.

The ICAR Director's Conference was organized on 13 April 2022. The Conference was held at the NASC Complex, New Delhi in physical mode and was formally inaugurated by Shri Narendra Singh Tomer, Hon'ble Minister of Agriculture and Farmers Welfare. Shri Parshottam Rupala, Hon'ble Minister of Animal Husbandry, Dairying and Fisheries participated as Special Guest. Hon'ble Ministers of State for Agriculture and Farmers Welfare Shri Kailash Chaudhary and Sushree Shobha Karandlaje participated as Guest of Honour. During the conference addressing the gathering, Hon'ble Minister observed that the Indian Council of Agricultural Research has been contributing significantly to the development of Indian Agriculture by strengthening the expansion of research and development, education and technologies. He further said that once we all get involved in expanding our participation in the welfare work with new energy and excitement, India's agriculture will progress rapidly on the path of progress. He called upon to take advantage of this opportunity to get together and make farmers welfare their goal and join this sacred task. The issues related to the ICAR institutes were discussed and resolved. Directors of all the ICAR Institutes including ATARIs and senior officials from ICAR HQs participated in the Directors' Conference.

The Regional Committee Meetings held once in every two-years, provide an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. The Committee provide a forum for liaison and coordination among the ICAR-Institutes, State Agricultural Universities (SAUs) and State Departments of Agriculture, Horticulture, Animal Husbandry and Fisheries. Secretaries of State Departments, 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 participated in the meeting, chaired by Secretary, DARE and DG, ICAR. The problems faced by the states in the areas of agriculture and related fields discussed and the solutions discussed and finalized. The actionable points were identified and assigned to the respective institutes/ universities/KVKs to resolve the issues. The action taken on the issues raised in the previous Regional Committee Meetings were also reviewed. Meeting of ICAR Regional Committee No. I comprising the States, viz. HP, J&K and Uttarakhand was held on 22 April 2022 through hybrid mode. This meeting was inaugurated by Shri Parshottam Rupala Hon'ble Minister of Animal Husbandry, Dairying and Fisheries. Meeting of ICAR Regional Committee No. II comprising the States, viz. West Bengal, Andhra Pradesh, Odisha and Andaman and Nicobar Islands was held on 14 October 2022 through hybrid mode at ICAR-NRRI, Cuttack. This meeting was inaugurated by Shri Kailash Chaudhary, Hon'ble Minister of State for Agriculture and Farmers Welfare. All these meetings were chaired by Secretary, DARE and DG, ICAR and attended by the officials from ICAR, Vice-Chancellors of State Agricultural Universities (SAUs) and State Departments of Agriculture, Horticulture, Animal

Swachhta Action Plan

Under Swachh Bharat Mission, Swachhta Action Plan (SAP) activities, viz. (i) Microbial-based Agricultural Waste Management using vermicomposting at Krishi Vigyan Kendras adopted villages, (ii) Management and Commercial Utilization of Fish Waste in 10 Fish Markets (in urban locations) and (iii) Phytoremediation for cleaning sewerage water for agricultural application to be replaced at different locations have been undertaken by various units of ICAR. SAP activity-wise progress reports for three quarters have been compiled and uploaded on the SAP Portal. An amount of ₹350 lakhs has been given for undertaking the SAP activities during the financial year 2021-22 and the similar amount has also been earmarked for the current financial year 2022-23. Apart from this, date-wise Action Plan for Swachhta Pakhwada (From 16-31 December) was prepared and regularly uploaded on the designated Portal of the Ministry of Jalshakti, Department of Drinking Water and Sanitation. Special Campaign 2.0 for disposal of pending matters from 2 October 2022 to 31 October 2022 was conducted successfully at the Council Headquarters as well as at all the Institutes of ICAR spread across India.

Husbandry and Fisheries. Secretaries of State Departments, Members of ICAR Governing Body, and Senior Officials from ICAR Headquarters, Directors and Scientists of ICAR Institutes in the region participated in the meeting.

During the financial year 2021-22 (up to 31 March 2022), the Council provided financial support of ₹1,50,53,357 to Societies/Associations/ Universities for holding National Seminars/ Symposia/Conferences. During the financial year 2022-23 (up to 31 October 2022), the Council provided financial support to 35 societies for publication of Scientific Journals. In addition, Societies/Associations/Universities were supported for holding National (25 Nos) and International (16 Nos) Seminars/Symposia/Conferences.

Annual Report of ICAR for the year 2021-2022 along with review statement was laid on the table of Lok Sabha on 5 April 2022 and Rajya Sabha on 1 April 2020. The Annual Account and Audit Report of ICAR for the year 2020-2021 along with review and delay statement was laid on the table of Lok Sabha and Rajya Sabha on 5 April 2022 and 1 April 2022, respectively. Besides laying above Reports, a total of 60 Parliament Questions were handled in the Division. Out of these, 18 Questions pertained, to Technical Coordination Division, whereas for remaining 42 Questions, inputs were provided to different Ministries/Departments. The Umbrella Memorandum of Understanding (UMoUs) signed between the ICAR and host Institutions, i.e. Central/ States Agricultural Universities. Total 54 such UMoUs signed with the Central/State Universities.

94th Foundation Day of ICAR and award ceremony

The Foundation Day was celebrated on 16 July 2022 at NASC Complex, New Delhi. The awards were given by Shri Narendra Singh Tomar, Hon'ble Minister for Agriculture, Shri Parshottam Rupala, Hon'ble Minister of Animal Husbandry, Dairying and Fisheries and Hon'ble Minister of State Shri Kailash Chaudhary. The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientists, teachers and farmers every year. Various ICAR Awards for the year 2021 were presented to the winners. The awards were given in 15 different categories to 94 awardees, these comprise 71 scientists (including 7 women) and 11 farmers (including 2 women farmers).

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20. Training and Capacity Building

The highlights of Training and Capacity Building of ICAR employees of all categories undertaken during 2021–22 are enumerated below.

Organization of online training workshop for Vigilance Officers of ICAR: An online training workshop for Vigilance Officers of ICAR Institutes was organized during 16–18 August, 2021 by ICAR-NAARM, Hyderabad in which 42 Vigilance Officers participated, all of them got this opportunity for the first time to participate in such type of programme after taking over the charge of Vigilance Officer.

Organization of online management development programme on PME: An online management development programme (MDP) on PME in Agricultural Research Projects was organized during 25–30 October, 2021 by ICAR-NAARM, Hyderabad in which 37 PME Cell Incharges and members of PME Cell participated, all of them got this opportunity for the first time to participate in such type of programme after taking over the charge of PME Cell Incharge/Member.

Organization of MDP for Effective Implementation of Training Functions: An online MDP for Effective Implementation of Training Functions in Institutes/HQs for HRD Nodal Officers/Co-Nodal Officers of ICAR was organized during 21–23 February, 2022 by ICAR-NAARM, Hyderabad in which 63 HRD Nodal Officers/Co-Nodal Officers of ICAR-Institutes participated, all of them got this opportunity for the first time to participate in such type of programme after taking over the charge of HRD Nodal Officer/Co-Nodal Officer.

Training programme on Good Agricultural Practices (GAPs) for Higher Productivity, Profitability and Resource-Use Efficiency: An online training programme on "Good Agricultural Practices (GAPs) for Higher Productivity, Profitability and Resource-use Efficiency" for technical staff of ICAR/non-ICAR Institutes was organized during 2–16 August, 2021 by ICAR-IARI, New Delhi in which 36 Technical staff participated, out of which 14 Technical staff got first time opportunity to participate in such type of programme after joining service.

Training programme on Appropriate Sampling Techniques Including Sample Preparation and Preservation for Soil, Water, Plant and Air Samples for Various Analyses: An online training programme on "Appropriate Sampling Techniques Including Sample Preparation and Preservation for Soil, Water, Plant and Air Samples for Various Analyses" for Technical staff of ICAR/non-ICAR Institutes was organized during 2–7 August, 2021 by ICAR-IARI, New Delhi in which 81 Technical staff participated, out of which 20 Technical got first time opportunity to participate in such type of programme after joining service.

Training programme on E-governance Application in ICAR: An online training programme on "E-governance Application in ICAR" for Technical staff of ICAR/non–ICAR Institutes was organized during 6–10 September, 2021 by ICAR-IASRI, New Delhi in which 59 Technical staff participated.

Training programme on Experimental Data Analysis: An online training programme on "Experimental Data Analysis" for Technical staff of ICAR/non-ICAR Institutes was organized during 20–29 October, 2021 by ICAR-IASRI, New Delhi in which 16 Technical staff participated.

Training programme on Statistical Techniques for Agricultural Data Analysis: An online training programme on "Statistical Techniques for Agricultural Data Analysis" for Technical staff of ICAR/non-ICAR Institutes was organized during 04–13 October, 2021 by ICAR-IASRI, New Delhi in which 116 Technical staff participated.

Training programme on Cyber Security: An online training programme on "Cyber Security" for Technical staff of ICAR/non–ICAR Institutes was organized during 2–7 March, 2022 by ICAR-IASRI, New Delhi in which 19 Technical staff participated.

Training programme on Pension and Retirement Benefits: A specialised training programme on ''Pension and Retirement Benefits" based on TNI for Administrative and Finance staff dealing with Pension and Retirement Benefits in ICAR Institutes and HQs was designed, developed and organized by ICAR-NRRI, Cuttack in coordination with HRM Unit and Finance Division, ICAR HQs during 12–14 January, 2022 in which 58 employees of such category from 38 ICAR Institutes/HQs participated, out of which all of them got this opportunity for the first time to participate in such type of programme after joining service.

Capacity Building Programme Towards a Secure and Resilient Workplace at ICAR: An online "Capacity Building Programme Towards a Secure and Resilient Workplace at ICAR" for Administrative/ Technical staff dealing with Security (Security Officer/ Supervisor) was organized during 1–3 September, 2021 by ICAR-CPRI, Shimla in coordination with HRM Unit, ICAR HQs in which 25 such category of staff of ICAR Institutes participated, out of which all of them got this opportunity for the first time to participate in such type of programme after joining service.

Training programme on Accrual Accounting: A specialised online training programme on "Accrual Accounting" based on TNI for Administrative and

Finance staff of ICAR Institutes/HQs and CAUs was organized by ICAR-NRRI, Cuttack in coordination with HRM Unit and Finance Division, ICAR HQs in which 153 Administrative and Finance staff participated in 3 batches, out of which all of them got this opportunity for the first time to participate in such type of programme after joining service.

Training programme on Assets Management: An online training programme on "Assets Management" for Administrative and Finance Staff of ICAR dealing with Assets Management in ICAR Institutes/HQs was organized during 6–8 October, 2021 by ICAR-IARI, New Delhi in coordination with HRM Unit and Finance Division, ICAR HQs in which 24 Administrative and Finance Staff participated, out of which all of them got this opportunity for the first time to participate in such type of programme after joining service.

Training programme on Repair and Maintenance of Office, Residential Building including Guest Houses: An online training programme on **"**Repair and Maintenance of Office, Residential Building including Guest Houses" for Administrative/Technical Staff dealing with Works/Estate/Building maintenance of ICAR was organized during 10–12 August**,** 2021 by ICAR-CIAE, Bhopal in coordination with HRM Unit and Works Division, ICAR HQs in which 43 Administrative/ Technical Staff participated, out of which all of them got this opportunity for the first time to participate in such type of programme after joining service.

Training programme on Establishment Matters for UDCs and LDCs: An online training programme on "Establishment Matters for UDCs and LDCs" was organized by ICAR-IISR, Lucknow in coordination with HRM Unit, ICAR HQs during 15–20 November, 2021 and 17–22 January, 2022 in 2 batches in which 83 UDCs and LDCs serving in various ICAR Institutes/ HQs participated, out of which all of them got this opportunity for the first time to participate in such type of programme after joining service.

Training on Living Heartfulness: Heartfulness Practices for Well-being and Harmony: An online training programme on "Living Heartfulness: Heartfulness Practices for Well-being and Harmony" was organized on 7 October, 2021 by HRM Unit, ICAR HQs with the support of Shri Ram Chandra Mission (SRCM), Heartfulness Institute, Kanha Village, Ranga Reddy District, Telangana in which about 35 Officers/ officials of ICAR HQs participated.

Publication of 100 New Training Modules: Hundred new Training Modules for all four categories of employees, i.e. Scientific, Technical, Administrative and SSS, was designed, developed and organized from 2015–2020 based on TNA have been documented and published. This would serve as reference/ready reckoner for various sectoral and functional groups of employees in ICAR, CAUs, SAUs, the entire NARES as a whole to enhance the competencies of the employees and performance of the Organization.

Nomination of employees in various training programmes: Nominated 734 employees of various categories in training and capacity building programmes organized by ISTM, New Delhi; AJNIFM, Faridabad; NRRI, Cuttack; IISR, Lucknow; NAARM, Hyderabad; CIAE, Bhopal; ASCI, Hyderabad; NPC, New Delhi; NIDM, New Delhi and DST, New Delhi, out of which 492 employees attended the training programmes.

Impact assessment of training programmes: Impact assessment of training attended by 2,115 employees of various categories during 2019–20 was done based on DoPT parameters**.** Based on the feedback of Trainees received from different ICAR Institutes, the overall Impact of training was Considerable-Great Extent with average rating of 3.72/5.00. Similarly, based on the feedback of Reporting Officers of the Trainees received from different ICAR Institutes, the overall impact of trainings on Trainees was also Considerable to Great Extent with average rating of 3.68/5.00.

Employees trained: During the reporting period, 2,834 employees have undergone various types of training and capacity building programmes, out of which Scientists, Technical, Administrative including Finance, and Skilled Support Staff (SSS) were 1,467, 621, 507 and 239, respectively even during the Covid-19 Pandemic situation, mostly through virtual mode. Compared to 2013–14, there was considerable improvement in number of employees who have undergone trainings where improvement was 5.3, 67.8 and 497.5% in Scientists, Technical and Skilled Support Staff, respectively along with overall improvement of 17.6% in all the categories of employees during 2021–22.

SMD-wise number of employees undergone training

SMDs/HQs	No. of employees trained					Per cent employees trained				
	Scientists	Tech.	Admin	SSS	Total	Scientists	Tech.	Admin	SSS	Total
Crop Science	471	184	163	56	874	26.9	13.5	19.8	4.0	16.4
Horticultural Science	229	78	92	96	495	32.4	12.6	24.7	22.2	23.2
NRM	251	157	54	41	503	34.6	20.1	15.3	8.1	21.3
Agricultural Education	67	22	6	0	95	45.9	29.3	6.3	0.0	24.5
Agricultural Engineering	74	60	44	27	205	39.2	26.0	37.9	29.7	32.7
Animal Science	200	68	69	3	340	27.4	9.6	13.2	0.2	10.6
Fisheries Science	153	47	55	16	271	26.7	9.7	18.6	5.4	16.4
Agricultural Extension	22	2	9	0	33	48.9	10.5	20.9	0.0	28.9
ICAR HQs	0	3	15	0	18	0.0	6.1	3.2	0.0	2.8
Total	1,467	621	507	239	2,834	29.7	14.3	16.4	5.8	17.2

Number of trainings organized by various SMDs/ICAR HQs

SMDs/HQs	Scientists (No.)	Technical Staff (No.)	Administrative Staff (No.)	SSS (No.)	All Employees (No.)
Crop Science	36	13	12	10	71
Horticultural Science	19	14	7	13	53
NRM	24	12	5	6	47
Agricultural Education	59	3	5	0	67
Agricultural Engineering	12	8	3	1	24
Animal Science	31	9	4	4	48
Fisheries Science	15	10	5	2	32
Agricultural Extension	14	7	0	0	21
ICAR HQs	1	4	4	1	10
Total	211	80	45	37	373

During the reporting period, Crop Science Division deputed highest number of Scientists (471), Technical (184) and Administrative including Finance staff (163), whereas Horticultural Division deputed the highest number of Skilled Support Staff (96) for various capacity building programmes. Thus, overall, maximum number of employees were trained in Crop Science Division (874) followed by NRM Division (503), out of 2,834 employees trained in the ICAR system.

In terms of per cent employees trained under each category, Scientists (29.7%), Technical (14.3%), Administrative including Finance (16.4%) and Skilled Support Staff (5.8%) were trained in various aspects as per their training needs during 2021–22 with overall 17.2% employees across the categories who got opportunity for capacity building. This is evident that 0.9, 7.0 and 5.1% more Scientists, Technical and Skilled Support Staff, respectively got training opportunities during 2021–22 as compared to 2013–14 with overall improvement of 4.5% in capacity building of all the categories of employees.

The training programmes organised for Scientists, Technical, Administrative including Finance, and Skilled Support Staff were 211, 80, 45 and 37, respectively. Compared to 2013–14, ICAR-Institutes organized 19.4 and 640.0% more training programmes for Technical and Skilled Support Staff, respectively during 2021–22. It is also being emphasized to give more opportunities outside ICAR in other competent and relevant Institutes. Though there was decline in number of trainings due to Covid-19 pandemic, the participation per training increased considerably.

Agricultural Education Division organised maximum number of trainings for scientists (59), Horticultural Science Division for technical staff (14) and Skilled Support Staff (13), and Crop Science Division for administrative staff (12). Moreover, maximum number of training programmes for all employees were organized by Crop Science Division (71) and was followed by Agricultural Education Division (67).

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21.
Publications and Social Media

The ICAR-Directorate of Knowledge Management in Agriculture (DKMA) is mandated to collate, compile and disseminate knowledge related to ICAR's technologies, policies and other activities through state-of-the-art dissemination methods that cater diversified stakeholders in the field of agriculture. In the fast changing knowledge intensive era, the DKMA is committed to encourage ICT-driven technology and create information dissemination systems including knowledge repositories for quicker and more effective outreach. The ICAR-DKMA publishes research and popular journals, books, handbooks, Annual Reports, newsletters, bulletins, monographs, e-books, media columns, social media contents, advisories, etc. The knowledge repositories are available in open access as well as in closed access modes for benefit of the national as well as global agricultural world. The Directorate makes sincere efforts to spread knowledge through social media and mass media for enhancing awareness about the latest developments and breakthroughs in agriculture.

Knowledge and information products

The Indian Journal of Agricultural Sciences and *The Indian Journal of Animal Sciences*, the flagship research journals of ICAR have been put on the open access mode (https://epubs.icar.org.in). The journals having international fame have a wide clientele. These journals received a total of 3,500 (Agricultural Sciences) and 1,928 (Animal Sciences) submissions, respectively during the reporting period. The user base of the journals is expanding and 3,273 and 2,125 new users have associated making the total tally to 40,926 (Agricultural Sciences) and 22,130 (Animal Sciences) users. The journal website was visited nearly 45,000 times with audience belonging to 143 countries. The journals have considerable metrics, viz. impact factor and H index are 0.37 and 29 for Agriculture and 0.31 and 23 for Animal sciences given the fact these are multi-disciplinary in nature.

Popular periodicals like *Indian Farming* and *Indian Horticulture* were brought out for outreach to the masses. Special issues of the *Indian Farming* were brought out on varied themes like Farmer FIRST Success Stories, Reimagining Rainfed Agro-ecosystems and International Year of Millets. A special issue of the *Indian Horticulture* was brought out on Plantation Crops.

During the year, Digital Object Identifier (DOI) number allotment to the articles for both the research journals was introduced which will benefit the authors as well as journal immensely. 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.

Under the books publication programme of the English Editorial Unit, six new titles were published namely Stingless Bees – An Unexplored Pollinator in India; Textbook of Ergonomics and Safety in Agriculture; Textbook on Forages; Ravine Land Management : Principles, Practices and Strategies; Textbook of Pet Animal Management; Textbook of Fundamentals of Agricultural and Animal Husbandry Extension; Textbook on Physical Chemistry and Mineralogy of soils; Textbook of Principles and Practices of Weed Management; Textbook of Environmental Agrometeorology; and Sugarcane Crop Management Practices in India.

The in-house publications like *ICAR Reporter*

and *ICAR News* are also available on ICAR website for wider global reach. These are viewed in about 140 countries world over.

For dissemination of latest information about the new technologies in ICAR's nationwide research network, the Hindi journals *Kheti* (monthly) and *Phalphul* (biomonthly) are continuing to play an important role. Both the journals were circulated through offline and online modes. The latest issues were uploaded for the readers and could be accessed free of cost. During the reported period six special issues of *Kheti* were published, namely 'success stories of farmers', 'livestock', 'climate change and agriculture', '75th year of publication of *Kheti*', 'Nutrition' and 'Millets'. Similarly two special issues of biomonthly Hindi journal *Phalphul*, namely Fruits, and Vegetables were published during this year. Both the Hindi journals cater to the needs of farmers, agriculture students, extension workers and progressive farmers to provide authentic scientific research based information regarding technological breakthroughs related to crops, livestocks, fisheries, horticulture crops, agro machines, government schemes etc. During the year, for aiding publication of the Hindi journals the e-patrika portal was developed. Apart from this a useful and informative book entitled *'Subziyon mein keeton aur rogon ka prabandhan'* was also published.

Business Unit

Apart from the routine work, Business Unit successfully organized/participated and facilitated the following exhibitions for showcasing ICAR technologies and publications during the reported period: (*i*) Pusa Krishi Vigyan Mela, New Delhi from 9-11 March 2022. (*ii*) 93rd Annual General Meeting of ICAR Society on 28 March 2022.

(*iii*) World Environment Expo, Pragati Maidan, New Delhi from 4-6 June 2022. (*iv*) ICAR Foundation Day Celebration on 16 July 2022. (*v*) ICAR-APAARI Workshop on Knowledge Management, NASC on 23 July 2022. (*vii*) ICAR Book Exhibition at Lala Lajpat Rai University of Veterinary and Animal Science, Hisar, Haryana on 28 and 29 October 2022. (*viii*) India Organic and Horti Expo at Dilli Haat, Janakpuri, Delhi from 4 to 6 November 2022. (*ix*) ICAR Book Exhibition at UP Pandit Deen Dayal Upadhyay Veterinary Science University, Mathura on 14 and 15 November 2022. (*x*) Indian International Trade Fair 2022 at Pragati Maidan, New Delhi from 14 to 27 November 2022.

The gross revenue of approximately ₹ 62.00 lakhs was realized from sale of publications during the period.

Social media

To disseminate information in real-time, the ICAR website is updated on a regular basis and in total 4,250 pages were updated and a total of 51,89,432 page views from more than 200 countries were recorded. Knowledge seekers across the globe visited the Website. The top five countries visiting the Website include India, United States of America, United Kingdom, United Arab Emirates and Nepal.

On ICAR Facebook, a total of 510 Posts were published during the year and it has 2,20,571 Followers.

ICAR Twitter Handle has more than 1,94,458 Followers. On an average, 3 Tweets are posted every day and a total of 1,020 Tweets were posted during the year .

The YouTube Channel of ICAR has Video Films, Animations, Lectures/Interviews by dignitaries and Eminent Scientists, Proceedings of National and International Events, etc. It has 63,300 Subscribers. ❑

APPENDIX 1

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2021-22 and BE 2022-23 in r/o DARE Secretariat, Contribution, AP Cess, 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
		2021-22	2021-22	2022-23
		Unified Budget	Unified Budget	Unified Budget
Major Head	**'3451'**			
090	**Secretariat-Economic Services**	732.00	707.00	790.00
091	**Agricultural Scientists' Recruitment Board**	0.00	0.00	2475.00
Major Head	**'2415'**			
80	**General**			
80.120	**Assistance to other institutions**			
01	**Grant-in-Aid Central Agricultural University Imphal**			
010031	Grantsin 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	550.00	550.00	550.00
020035	Grants forcreation of Capital Assets	9695.00	9695.00	10495.00
020036	Grants in Aid Salaries	850.00	1050.00	1600.00
03	**Grant-in-Aid Central Agricultural University Bihar**			
030031	Grants in Aid General	1500.00	1500.00	1500.00
030035	Grants for creation of Capital Assets	4500.00	4500.00	4500.00
030036	Grants in Aid Salaries	9000.00	12700.00	14500.00
05	**Grants-in-Aids to National Academy of Agricultural Sciences and Indian Agricultural Universities Association**			
050031	Grantsin Aid General	160.00	160.00	160.00
050035	Grants for creation of Capital Assets	-	-	-
050036	Grants in Aid Salaries	-	-	-
06	**Agricultural Scientists' Recruitment Board**			
060031	Grants in Aid General	900.00	900.00	-
060035	Grants for creation of Capital Assets	350.00	1150.00	-
060036	Grants in Aid Salaries	650.00	600.00	-
80.798	**International Co-operation (Minor Head)**			
01	**India's Membership Contribution to Common wealth Agricultural Bureau**			
010032	Contribution	60.00	60.00	60.00
02	**India's Membership Contribution to Consultative Group on International Agricultural Research**			
020032	Contribution	550.00	580.00	580.00
04	**Asia Pacific Association of Agricultural Research Institutions**			
040032	Contribution	10.00	10.00	10.00
05	**N.A.C.A.**			
050032	Contribution	48.00	48.00	48.00
07	**International Seed Testing Association, Zurich, Switzerland**			
070032	Contribtion	5.00	4.00	5.00
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	2500.00	2500.00	2500.00
010035	Grants for creation of Capital Assets	5500.00	5500.00	5500.00
010036	Grants in Aid Salaries	13000.00	18300.00	18800.00
	TOTAL	**50560.00**	**60514.00**	**64073.00**

Notes on Demands For Grants, 2022-2023

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)

Schemes		Actual 2020-2021			Budget 2021-2022			Revised 2021-2022			Budget 2022-2023		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
	Gross	7685.51	...	7685.51	8513.62	...	8513.62	8513.62	...	8513.62	8513.62	...	8513.62
	Recoveries	-131.74	...	-131.74	...	...	...	...	...	...	...	...	...
	Receipts	...	...	...	...	...	...	...	...	...	...	...	...
	Net	7553.77	...	7553.77	8513.62	...	8513.62	8513.62	...	8513.62	8513.62	...	8513.62
I Establishment Expenditure of the Centre													
1. Secretariat	2415	6.60	...	6.60	6.73	...	6.73	7.02	...	7.02	7.03	...	7.03
	3451	5.98	...	5.98	7.32	...	7.32	7.07	...	7.07	32.65	...	32.65
Total -Secretariat		**12.58**	**...**	**12.58**	**14.05**	**...**	**14.05**	**14.09**	**...**	**14.09**	**39.68**	**...**	**39.68**
II Central Sector Schemes/Projects													
2. Agricultural Extension	2415	236.72	...	236.72	282.10	...	282.10	243.89	...	243.89	209.61	...	209.61
	2552	...	...	...	45.90	...	45.90	40.11	...	40.11	34.11	...	34.11
Total-Agricultural Extension		**236.72**	**...**	**236.72**	**328.00**	**...**	**328.00**	**284.00**	**...**	**284.00**	**243.72**	**...**	**243.72**
3. Agricultural Engineering	2415	58.31	...	58.31	62.00	...	62.00	52.38	...	52.38	46.07	...	46.07
	2552	...	...	...	3.00	...	3.00	2.62	...	2.62	2.23	...	2.23
Total-Agricultural Engineering		**58.31**	**...**	**58.31**	**65.00**	**...**	**65.00**	**55.00**	**...**	**55.00**	**48.30**	**...**	**48.30**
Management of Natural Resources													
4. Natural Resource Management Institutes including Agro Forestry Research	2415	170.43	...	170.43	152.00	...	152.00	130.43	...	130.43	112.95	...	112.95
	2552	...	...	...	43.00	...	43.00	37.57	...	37.57	31.95	...	31.95
Total-Natural Resource Management Institutes including Agro Forestry Research		**170.43**	**...**	**170.43**	**195.00**	**...**	**195.00**	**168.00**	**...**	**168.00**	**144.90**	**...**	**144.90**
5. Climate Resilient Agriculture Initiative	2415	49.83	...	49.83	49.50	...	49.50	42.19	...	42.19	36.78	...	36.78
	2552	...	...	...	5.50	...	5.50	4.81	...	4.81	4.09	...	4.09
Total-Climate Resilient Agriculture Initiative		**49.83**	**...**	**49.83**	**55.00**	**...**	**55.00**	**47.00**	**...**	**47.00**	**40.87**	**...**	**40.87**
Crop Sciences													
6. Crop Science	2415	592.59	...	592.59	640.80	...	640.80	556.28	...	556.28	476.15	...	476.15
	2552	...	...	...	67.20	...	67.20	58.72	...	58.72	49.93	...	49.93
Total-Crop Science		**592.59**	**...**	**592.59**	**708.00**	**...**	**708.00**	**615.00**	**...**	**615.00**	**526.08**	**...**	**526.08**
7. Horticultural Science	2415	175.72	...	175.72	180.00	...	180.00	155.04	...	155.04	133.76	...	133.76
	2552	...	...	...	32.00	...	32.00	27.96	...	27.96	23.77	...	23.77
Total-Horticultural Science		**175.72**	**...**	**175.72**	**212.00**	**...**	**212.00**	**183.00**	**...**	**183.00**	**157.53**	**...**	**157.53**
8. National Agricultural Science Fund	2415	37.06	...	37.06	48.00	...	48.00	42.00	...	42.00	35.67	...	35.67
Animal Sciences													
9. Animal Science		256.38	...	256.38	269.00	...	269.00	233.17	...	233.17	199.89	...	199.89
	2552	...	...	...	33.00	...	33.00	28.83	...	28.83	24.52	...	24.52

Contd..

(Concluded)

Schemes		Actual 2020-2021			Budget 2021-2022			Revised 2021-2022			Budget 2022-2023		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Total-Animal Science		**256.38**	**...**	**256.38**	**302.00**	**...**	**302.00**	**262.00**	**...**	**262.00**	**224.41**	**...**	**224.41**
10. Fisheries Science	2415	143.81	...	143.81	156.00	...	156.00	134.50	...	134.50	115.92	...	115.92
	2552	...	...	...	4.00	...	4.00	3.50	...	3.50	2.97	...	2.97
Total -Fisheries Science		**143.81**	**...**	**143.81**	**160.00**	**...**	**160.00**	**138.00**	**...**	**138.00**	**118.89**	**...**	**118.89**
Agricultural Education													
11. Agricultural Universities and Institutions	2415	316.68	...	316.68	320.00	...	320.00	269.42	...	269.42	237.76	...	237.76
	2552	...	...	...	35.00	...	35.00	30.58	...	30.58	26.01	...	26.01
Total -Agricultural Universities and Institutions		**316.68**	**...**	**316.68**	**355.00**	**...**	**355.00**	**300.00**	**...**	**300.00**	**263.77**	**...**	**263.77**
12. Economic Statistics and Management	2415	29.46	...	29.46	33.00	...	33.00	28.00	...	28.00	24.51	...	24.51
13. National Agricultural Higher Education Project (EAP)		180.00	...	180.00	225.00	...	225.00	225.00	...	225.00	167.18	...	167.18
Total -Central Sector Schemes/Projects		**2246.99**	**...**	**2246.99**	**2686.00**	**...**	**2686.00**	**2347.00**	**...**	**2347.00**	**1995.83**	**...**	**1995.83**
III Other Central Sector Expenditure													
b Autonomous Bodies													
14. ICAR Headquarters		4984.93	...	4984.93	5152.02	...	5152.02	5433.98	...	5433.98	5877.06	...	5877.06
	2552	...	...	...	170.00	...	170.00	127.50	...	127.50	...	...	...
		4984.93	...	4984.93	5322.02	...	5322.02	5561.48	...	5561.48	5877.06	...	5877.06
15. Central Agricultural Universities	2415	427.96	...	427.96	260.95	...	260.95	299.95	...	299.95	331.45	...	331.45
	2552	...	...	...	210.00	...	210.00	263.00	...	263.00	268.00	...	268.00
		427.96	...	427.96	470.95	...	470.95	562.95	...	562.95	599.45	...	599.45
16. National Academy of Agricultural Sciences	2415	1.60	...	1.60	1.60	...	1.60	1.60	...	1.60	1.60	...	1.60
17. Agricultural Scientists Recruitment Board		11.45	...	11.45	19.00	...	19.00	26.50	...	26.50	...	...	...
Total -Autonomous Bodies		**5425.94**	**...**	**5425.94**	**5813.57**	**...**	**5813.57**	**6152.53**	**...**	**6152.53**	**6478.11**	**...**	**6478.11**
f Others													
18. Actual Recoveries		-131.72	...	-131.72	...	...	...	...	...	...	...	...	...
	3451	-0.02	...	-0.02	...	...	...	...	...	...	...	...	...
		-131.74	...	-131.74	...	...	...	...	...	...	...	...	...
Grand Total -		**7553.77**	**...**	**7553.77**	**8513.62**	**...**	**8513.62**	**8513.62**	**...**	**8513.62**	**8513.62**	**...**	**8513.62**
B. Developmental Heads													
Economic Services													
1. Agricultural Research and Education		7547.81	...	7547.81	7857.70	...	7857.70	7881.35	...	7881.35	8013.39	...	8013.39
2. Secretariat-Economic Services		5.96	...	5.96	7.32	...	7.32	7.07	...	7.07	32.65	...	32.65
Total -Economic Services		**7553.77**	**...**	**7553.77**	**7865.02**	**...**	**7865.02**	**7888.42**	**...**	**7888.42**	**8046.04**	**...**	**8046.04**
Others													
3. North Eastern Areas		...	...	...	648.60	...	648.60	625.20	...	625.20	467.58	...	467.58
Total -Others		**...**	**...**	**...**	**648.60**	**...**	**648.60**	**625.20**	**...**	**625.20**	**467.58**	**...**	**467.58**
Total -		**7553.77**	**...**	**7553.77**	**8513.62**	**...**	**8513.62**	**8513.62**	**...**	**8513.62**	**8513.62**	**...**	**8513.62**
01 Agrinnovate India Limited		...	5.11	5.11	...	...	...	...	3.49	3.49	...	5.00	5.00

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 and mitigation covers crops, livestock, fisheries and natural resource management.
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.
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. The provision is for conducting research in the areas of agricultural economics and agricultural statistics to address the policy, management and database issues and accordingly provide need-based support to other schemes and agricultural stakeholders.
13. 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.
14. Provision is primarily for the salaries, pensions, expenses on administrative and logistic support to different schemes under ICAR in order to implement them efficiently.
15. The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation.
16. 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.
17. The provisions are for the creation of an separate body which would be responsible for the recruitment to posts in the Agricultural Research Service (ARS) of the ICAR and other group A posts in ICAR.

APPENDIX 2

DEPARTMENTAL ACCOUNTING ORGANIZATION
Accounting Organization of Department of Agricultural Research and Education

The Secretary as Chief Accounting Authority in the Department of Agricultural Research and Education discharges his functions with the assistance of Financial Adviser and Chief Controller of Accounts.

1. As per Rule 70 of GFR 2017, the Secretary of a Ministry/Department as Chief Accounting Authority of the Ministry/Department shall:

(*i*) Be responsible and accountable for financial management of his Ministry or Department;

(*ii*) Ensure that the public funds appropriated to the Ministry or Department are used for the purpose for which they were meant;

(*iii*) Be responsible for the effective, efficient, economical and transparent use of the resources of the Ministry or Department in achieving the stated project objectives of that Ministry or Department, whilst complying with performance standards;

(*iv*) Appear before the Committee on Public Accounts and any other Parliamentary Committee for examination;

(*v*) Review and monitor regularly the performance of the programmes and projects assigned to his Ministry to determine whether stated objectives are achieved;

(*vi*) Be responsible for preparation of expenditure and other statements relating to his Ministry or Department as required by regulations, guidelines or directives issued by Ministry of Finance;

(*vii*) Ensure that his Ministry or Department maintains full and proper records of financial transactions and adopts systems and procedures that shall at all time afford internal controls;

(*viii*) Ensure that his Ministry or Department follows the Government procurement procedure for execution of works, as well as for procurement of services and supplies, and implements it in a fair, equitable, transparent, competitive and cost-effective manner;

(*ix*) Take effective and appropriate steps to ensure his Ministry or Department:-

(a) Collects all moneys due to the Government and

(b) Avoids unauthorized, irregular and wasteful expenditure.

2. As per Para 1.3 of Civil Accounts Manual, the Chief Controller of Accounts for and on behalf of the Chief Accounting Authority is responsible for:

(a) Arranging all payments through the Pay and Accounts Offices/Principal Accounts Office except where the Drawing and Disbursing Officers are authorized to make certain types of payments.

(b) Compilation and consolidation of accounts of the Ministry/Department and their submission in the form prescribed, to the Controller General of Accounts; preparation of Annual Appropriation Accounts for the Demands for Grants of his Ministry/Department, getting them duly audited and submitting them to the CGA, duly signed by the Chief Accounting Authority.

(c) Arranging internal inspection of payment and accounts records maintained by the various subordinate formations and Pay and Accounts Offices of the Department and inspection of records pertaining to transaction of Government Ministries/Departments, maintained in Public Sector Banks.

3. The Chief Controller of Accounts, Ministry of Agriculture and Farmers Welfare performs his duties with the assistance of Controller/Assistant Controller of Accounts, three Principal Accounts Officer sat HQ and 09 Pay and Accounts Offices. Four Pay and Accounts Offices are located in Delhi/NCR, One each in Mumbai, Chennai, Cochin, Kolkata and Nagpur. All payments pertaining to the Department /Ministry are made through PAOs/CDDOs attached with respective PAOs. DDOs present their claims/bills to the designated PAOs/CDDOs, who issue cheques/ releases e-payment after exercising the necessary scrutiny as per provisions contained in Civil Accounts Manual, Receipt and Payment Rules and other order issued by Government from time to time.

4. As per Para 1.2.3 of Civil Accounts Manual, Principal Accounts Office at HQ functions under a Principal Accounts Officer who is responsible for:

(a) Consolidation of the accounts of the Ministry/ Department in the manner prescribed by CGA;

(b) Preparation of Annual Appropriation Accounts of the Demands for Grants controlled by Ministry/Department, submission of Statement of Central Transactions and material for the Finance Account of the Union Government (Civil) to the Controller General of Accounts;

(c) Payment of loans and grants to State Government through Reserve Bank of India and wherever this office has a drawing account, payment therefrom to Union Territory Government/Administrations;

(d) Preparation of manuals keeping in view the objective of management accounting system if any, and for rendition of technical advice to Pay and Accounts Offices, maintaining necessary liaison with CGA's Office and to effect overall coordination and control in accounting matters;

(e) Maintaining Appropriation Audit Registers for the Ministry/Department as a whole to watch the progress of expenditure under the various Grants operated on by the Ministry/Department;

Principal Accounts Office/Officer also performs all administrative and coordinating function of the accounting organization and renders necessary financial, technical, accounting advice to department as well as to local Pay & Accounts offices and Out Station Pay & Accounts offices.

5. As per provisions contained in Civil Accounts Manual,

(f) Pay & Accounts offices make payments pertaining to respective Ministries/Departments and in certain cases payments will be made by the departmental Drawing and Disbursing Officers (DDOs) authorized to draw funds, by means of cheques drawn on the offices/branches of accredited bank for handling the receipts and payments of the Ministry/Department. These payments will be accounted for in separate scrolls to be rendered to the Pay and Accounts Offices of Ministry/Department concerned. Each Pay and Accounts Office or Drawing and Disbursing Officer authorized to make payments by cheques/e-payments, will draw only on the particular branch/branches of the accredited bank with which the Pay and Accounts Office or the Drawing and Disbursing Officer as the case may be, is placed in account. All receipts of the Ministry/Department are also be finally accounted for in the books of the Pay and Accounts Office. The Pay and Accounts office is the basic Unit of Departmentalized Accounting Organization. Its main function include:

(a) Pre-check and payment of all bills, including those of loans and grants-in-aid, submitted by Non-Cheque Drawing DDOs.

(b) Accurate and timely payments in conformity with prescribed rules and regulations.

(c) Timely realization of receipts

(d) Issue of quarterly letter of credit to Cheque Drawing DDOs and post check of their Vouchers/bills.

(e) Compilation of monthly accounts of receipts and expenditures made by them incorporating there with the accounts of the cheque Drawing DDOs.

(f) Maintenance of GPF accounts other than merged DDO and authorization of retirement benefits.

(g) Maintenance of all DDR Heads.

(h) Efficient service delivery to the Ministry/ Department through banking arrangement by way of e-payment.

(i) Adherence to the prescribed Accounting Standards, rules and principles.

(j) Timely, accurate, comprehensive, relevant and use ful financial reporting.

6. The overall responsibilities of Departmental Accounting Organization in respect of Ministry of Agriculture and Farmers Welfare are:

(a) Consolidation of monthly accounts of Ministry and its submission to the CGA.

(b) Annual Appropriation Accounts.

(c) Statement of Central Transactions.

(d) Preparation of "Accounts at a Glance".

(e) Union Finance accounts which are submitted to the CGA, Ministry of Finance and Principal Director of Audit.

(f) Payments of grants-in-aid to Grantee Institutions/ Autonomous Bodies etc.

(g) Rendering technical advice to all PAOs and Ministry; if necessary in consultation with other organizations like DoPT, Ministry of Finance and CG Aetc.

(h) Preparation of Receipt Budget.

(i) Preparation of Pension Budget.

(j) Procuring and supplying of cheque books for

And on behalf of PAOs/Cheque Drawing DDOs.

(k) To maintain necessary liaison with Controller General of Accounts office and to effect overall co-ordination and control in accounting matters and accredited Bank.

(l) To verify and reconcile all receipts and payments made on behalf of Ministry of Agriculture and Farmers Welfare through the accredited Bank, i.e. State Bank of India.

(m) To maintain accounts with Reserve Bank of India relating to Ministry of Agriculture and Farmers Welfare and to reconcile the cash balances.

(n) To ensure prompt payments.

(o) Speedy settlement of Pension/Provident fund and other retirement benefits.

(p) Internal Audit of the Ministry, subordinate and attached offices under Ministry of Agriculture and Farmers Welfare and its Grantee institutions, Autonomous Bodies etc.

(q) To make available accounting information to all concerned Authorities/Divisions.

(r) Budget co-ordination works of Ministry of Agriculture and Farmers Welfare.

(s) Monitoring of New Pension Scheme and revision of pension cases from time to time.

(t) Computerization of Accounts and e-payment.

(u) Administrative and co-ordination function of the accounting organization.

(v) Roll out of PFMS under Central Sector Schemes in Grantee Institutions/Autonomous Bodies.

(w) Non-Tax Receipt Portal (NTRP) in Ministry of Agriculture and Farmers Welfare.

7. Accounting information and data are also provided to the Financial Advisor and Chief Accounting Authority to facilitate effective budgetary and financial control. Monthly and progressive expenditure figures under various sub-heads/object-head soft he grant of the Ministry of Agriculture and Farmers Welfare are furnished to Budget Section of the Ministry including Senior officers. Progress of expenditure against budget provisions are also submitted weekly to the Secretary and Addl. Secretary and Financial Adviser as well as Heads of Divisions of the Ministry, controlling the grant for purposes of better monitoring of expenditure in last quarter of the financial year.

8. The Accounting organization also maintains accounts of long-term advances such as House Building Advance, Motor Car Advance and GPF accounts of employees of the Ministry.

9. The verification and authorization of pensionary entitlement of officers and staff member sis done by the Pay & Accounts Offices on the basis of service particular sand pension papers furnished by Heads of Offices. All retirement benefits and payments like gratuity, cash equivalent to leave salary as well as payments under Central Government Employees Group Insurance Scheme; General Provident Fund etc. are released by Pay & Accounts Offices on receipt of relevant information/ bills from DDOs.

Department	Outstanding paras up to 31.03.2022	Paras raised from 01.04.2022 to 30.06.2022	Paras dropped from 01.04.2022 to 30.06.2022	Total outstanding Paras as on 30.06.2022
DARE	Nil	Nil	Nil	Nil
ICAR Units	Nil	Nil	Nil	Nil
Total	Nil	Nil	Nil	Nil
Department	Outstanding paras up to 30.06.2022	Paras raised from 01.07.2022 to 30.09.2022	Paras dropped from 01.04.2022 to 30.09.2022	Total outstanding Paras as on 30.09.2022
DARE	Nil	Nil	Nil	Nil
ICAR Units	Nil	32	Nil	32
Total	Nil	32	Nil	32

Internal Audit Wing

(a) The Internal Audit Wing carries out audit of accounts of various offices of the Ministry to ensure that rules, regulations and procedures prescribed by the government are adhered to by these offices in their day to day functioning. Internal Auditing is an independent, objective assurance and consulting activity designed to add value and improve an organization's operations. It basically aims at helping the organization to accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control and governance processes. It is also an effective tool for providing objective assurance and advice that adds values, influence change that enhances governance, assist risk management, control processes and improve accountability for results. It also provides valuable information to rectify the procedural mistakes/deficiencies and thus, acts as ana id to the management. The periodicity of audit of a unit is regulated by its nature, volume of work and quantum of funds.

(b) The Internal Audit Wing working under the overall guidance of Chief Accounting Authority and Financial Advisor has focused on strengthening governance structures, capacity building and leveraging technology in appropriate manner to ensure an efficient and effective Internal Audit practice.

(c) In pursuance of O/o Controller General of Accounts, Department of Expenditure, Ministry of Finance, OM no. G.25014/33/2015-16/MF.CGA/IAD/306-53 dated 15.05.17 and as per provisions contained in Generic Internal Audit Manual (Version 1.0) issued by O/o CGA, Audit Committee has been constituted in this Department under the Chairmanship of Secretary (DARE) and DG(ICAR) with the approval of Secretary (DARE) and DG (ICAR) and terms of reference of Internal Audit Committee has been defined in O/o CCA OM No. Agri/ IAW/Audit Committee (DARE)/2022–23(Computer File No. 197946)/523-532 dated 15.09.2022.

(d) During the financial year 2022–23, the focus of Audit was to detect errors in fixation of Pay paid in excess as well as in short.

Status of Outstanding Internal Audit paras in the Department of Agricultural Research and Education (DARE) as on 30.09.2022 are given below:

Banking Arrangements

State Bank of India is the accredited bank for PAOs and its field offices in the Ministry of Agriculture and farmers Welfare. e-payments processed by the PAOs/CDDOs are settled through CMP, SBI, Hyderabad in favour of the bank account of vendors/beneficiaries. In some cases, Cheques issued by the PAOs/CDDOs are presented to the nominated branch of the accredited bank for payment. The receipts are also remitted to the accredited banks by the respective PAOs/CDDOs apart from Non-Tax-Receipt Portal (NTRP). Any change in accredited bank requires specific approval of Controller General of Accounts, Department of Expenditure, Ministry of Finance.

Principal Accounts Office has 09 (Nine) Pay & Accounts Offices. Four PAOs are located in Delhi/NCR, One each in Mumbai, Chennai, Cochin, Kolkata and Nagpur. All payments pertaining to the Department/Ministry are made through PAOs/CDDOs attached with respective PAOs. Drawing/bills to the designated PAOs/CDDOs, who issue releases e- payment after exercising the necessary scrutiny as per provisions contained in Civil Accounts Manual, Receipt and Payment Rules and other orders issued by Govt. from time to time.

Initiatives one-payment

The e-payments system in all Pay & Accounts Offices of Ministry of Agriculture and Farmers Welfare had been successfully implemented from 2011 onwards.

e-Payment System

Since, the IT Act, 2000 recognizes the digitally signed documents or electronic records digitally authenticated by means of an electronic method or procedure in accordance with the provisions of section 3 of the Act, the Controller General of Accounts had developed a facility in COMPACT for electronic payment (e-payment) through digitally signed electronic advices. This had replaced the existing system of payment through cheque while leveraging the COMPACT application running in all Pay & Accounts Offices in all Ministries/Departments of Central Government.

The e-payment system developed was a fully secured web based system of electronic payment services which introduces transparency in government payment system. Payment of dues from the government under this system were made by credit of money directly into the bank account of payee through a digitally signed-advices generated from COMPACT through the 'Government e-payment Gateway (GePG)' on a secured communication channel. Necessary functional and security certification were obtained from STQC Directorate for its roll out. The system was implemented in all Central Government Civil Ministries/Departments in a phased manner.

GePG has further been upgraded to PFMS system, which is an integrated Financial Management System of Controller General of Accounts, for sanction preparation, bill processing, payment, receipt management, Direct Benefit Transfer, fund flow management and financial reporting.

Public Financial Management System (PFMS)

Public Financial Management System (PFMS) initially started as a Plan Scheme named CPSMS of the erstwhile Planning Commission in 2008-09 as a pilot in four states of Madhya Pradesh, Bihar, Punjab and Mizoram for four Flagship schemes, e.g MGNREGS, NRHM, SSA and PMGSY. After the initials phase of establishing a network across Ministries/Departments, It has been decided to undertake National roll-out of CPSMS (PFMS) to link the financial networks of Central, State Governments and the agencies of State Governments. The scheme was included in 12th Plan initiatives of erstwhile Planning Commission and Ministry of Finance. Presently PFMS is the scheme of Department of Expenditure, Ministry of Finance and being implemented by O/o Controller General of Accounts across the country.

1. As per MoF, DoE, OM No.66 (29) PF-II/2016 dated 15/07/2016, Hon'ble Prime Minister has emphasized the need for improved financial management in implementation of Central Plan Schemes so as to facilitate Just-in-Time releases and monitor the usage of funds including information on its ultimate utilization. The Public Financial Management System (PFMS) is administered by the O/o controller General of Accounts in the Department of Expenditure which is an end-to-end solution for processing payments, tracking, monitoring, accounting, reconciliation and reporting. It provides the scheme managers a unified platform for tracking releases and monitoring their last mileutilization.
2. In order to abide by the directions to implement Just-in-time releases and monitor the end usage of funds, it has been decided by Ministry of Finance to universalize the use of PFMS to cover all transactions/payments under the Central Sector Schemes. The complete monitoring of these schemes require mandatory registration of all Implementing Agencies (IAs), on PFMS and mandatory use of Expenditure Advances & Transfer (EAT) module of the PFMS by all IAs. The Implementation Plan covers the complete universe of Central Sector Schemes, which inter-alia requires the following steps to be taken by each Ministry/Department:

(*i*) All central schemes have to be mapped /configured and brought on the PFMS platform.

(*ii*) All Implementing Agencies (IAs) receiving and utilizing funds needs to be mandatorily registered on PFMS.

(*iii*) Usage of PFMS modules has to be made mandatory for all registered agencies for making payments, advances and transfers.

(*iv*) All Departmental Agencies incurring expenditure in respect of Central Sector Schemes must register and compulsorily use the PFMS Modules.

(*v*) All Grantee Institutions have to adopt PFMS modules for making Payments/Transfers/Advance from Grants received from the Central Govt. This will enable generation of on-line Utilization Certificates for claiming funds from the Central Government.

(*vi*) Ministry has to take an action for integrating their respective systems/applications with the PFMS.

Modules to implement the Mandate

Modules developed/under developed by PFMS for stakeholders as per the Union Cabinet approval and mandate are as under:

Fund Flow Monitoring [EAT Modules]

(a) Agency registration

(b) Expenditure management and fund utilization through PFM SEAT module

(c) Accounting Modulef or registered agencies

(d) Treasury Interface

(e) PFMS-PRI fund flow and utilization interface

(f) Mechanism for State Governments towards fund tracking for States chemes

(g) Monitor in gof Externally Aided Projects (EAP)

II. Direct Benefit Transfer (DBT) modules

(a) PAO to beneficiaries

(b) Agency to beneficiaries

(c) State treasuries to beneficiaries

III. Interfaces for Banking

(a) CBS (Core Banking Solutions)

(b) India Post

(c) RBI (Reserve Bank of India)

(d) NABARD and Cooperative Banks

Modules to Implement Enhanced mandate

1. PAO Computerization-Online payments, receipts and accounting of Government of India

(a) Programme Division module

(b) DDO module

(c) PAO module

(d) Pension module

(e) GPF and HR module

(f) Receipts including GSTN

(g) Annual Financial Statements

(h) Cash Flow Management

(i) Interface with non-civil ministries

2. Non-Tax Receipt Portal.

Other Departmental Initiatives

To leverage the capabilities of PFMS, several other departments have approached PFMS for developing utilities for their departmental need as follows:

(i) CBDTPAN Validation

(ii) GSTN bank account validation

Implementation Strategy

An Action Plan has been prepared and approved by Ministry of Finance for phased implementation of Public Financial Management System (PFMS).

Improved Financial Management through

Just in Time (JIT) release of funds

Monitoring of use of funds including ultimate utilization

Strategy

Universal roll-out of PFMS which inter alia includes

- Mandatory registration of all Implementing Agencies (IA) on PFMS and
- Mandatory use of Expenditure Advance & Transfer (EAT) Module of PFMS by all IAs.

I. Implementation Strategy for Central Sector (CS) schemes/ transaction

- Activities to be completed
- Mandatory registration and use of EAT module by IAs
- Mapping of all relevant information of Schemes
- Uploading of budget of each scheme on PFMS
- Identify implementation hierarchy of each scheme
- Integration of System Interface of specific schemes with PFMS, e.g. NREGA Soft, Awas Soft
- Deployment and training of trainers

II. Implementation Strategy for Centrally Sponsored Schemes

Activities to be undertaken by states

- State Treasury Integration with PFMS
- Registration of all SIAs on PFMS (1st level and below)
- Mapping of state schemes with corresponding central schemes
- Configuration of State schemes on PFMS
  - Configuring State Schemes components
  - Identify and configure hierarchy of each state scheme
- Integration of PFMS with schemes specific soft ware application
- Deployment and training of trainers
- Continuous support for implementation

At present, all nine (09) Pay & Accounts Offices of M/o Agriculture Farmer Welfare, four (4) PAOs are located in Delhi/NCR, One each in Mumbai, Chennai, Cochin, Kolkata and Nagpur are functioning successfully on PFMS. All payments are routed through PFMS and e-payments being directly credited into the beneficiary's bank account.

I. ***Employees Information System (EIS) Module of PFMS:*** This Module has been implemented in all Drawing and Disbursing Offices of Ministry of Agriculture and Farmer welfare.

II. ***CDDO Module of PFMS:*** CDDO module of PFMS has been rolled out in all Cheque Drawing and Disbursing Offices of Ministry of Agriculture and Farmer Welfare.

III. ***Online Portal (Bharatkosh) for collection of Non-Tax Revenue in the Ministry:***

- The objective of Non-Tax Receipt Portal (NTRP) is to provide a one-stop window to Citizens/Corporate/Other users for making online payment of Non-Tax Revenue payable to Government of India (GoI).
- Non-Tax Revenue of Government of India comprise of a large bouquet of receipts, collected by individual departments/ministries. Primarily these receipts come from Dividends, Interest receipts, Spectrum charges, RTI application fee, purchase of forms/magazines by students and many other such payments by citizens/ corporate/other users.
- The online electronic payment in a completely secured IT environment, helps common users /citizen from the hassle of going to banks for making drafts and then to Government offices to deposit the instrument for availing the services. It also helps avoidable delays in the remittance of these instruments into Government account as well as eliminates undesirable practices in the delayed deposit of these instruments into bank accounts.
- NTRP facilitates instant payment in a transparent environment using online payment technologies such as Internet Banking, Credit/Debit Cards.
- NTR Portal has been functional in new Ministry of Agriculture and Farmers Welfare since inception in FY 2019-20.
- Expenditure, Advance and Transfer (EAT)Module of PFMS: All eight (08) Autonomous Bodies of Ministry of Agriculture & Farmer Welfare have been on-boarded on Expenditure Advance Transfer (EAT) module of PFMS.
- **Treasury Single Account (TSA)**
- The Expenditure Management Commission (EMC) vide Para 125 of its September, 2015 report has recommended that in order to minimize the cost of Government borrowings and to enhance efficiency in fund flows to Autonomous Bodies, Government should gradually bring all Autonomous Bodies (ABs) under the Treasury Single Account (TSA)System.

Under Department of Agricultural Research and Education, the TSA is implemented in the following:

- Indian Council of Agricultural Research(ICAR)
- Central Agriculture University, Imphal

The details of the Budgetary Provision and Expenditure their against is reflected below:

- Ministry of Finance, Department of Expenditure Vide Office Memorandum F.No. 26(118)/EMC Cell/2016 dated 24.02.2022 has issued "Revised instructions on bringing Autonomous Bodies (ABs) under the Treasury Single Account (TSA) System".
- Ministry of Finance, Department of Expenditure Vide Office Memorandum F.No. 26(118)/EMC Cell/2016 dated 20.10.2022 has issued "Amendment in revised guidelines for implementing Treasury Single Account (TSA) System in Autonomous Bodies (Abs)", which states that "these guidelines shall be applicable to Autonomous Bodies (ABs) including Statutory Bodies and Central Public Sector Enterprises (CPSEs) receiving more than Rs. 100.00 crores in a F.Y. as Grants-in-Aid".
- This amendment will be effective from 1st April, 2023.

New Developments in the Ministry

I. Enforcement of enhanced security layers in online payment process in Public Financial Management System (PFMS)

TSA Figures as on 30-09-2022

(₹. in Crore)

Name of ABs	Budget Estimate	Releases	%of Releases
Central Agricultural University, Imphal	268	134	50%
ICAR Headquarters	7872.89	3936.35	49.99%

In order to ensure safety measures on PFMS platform, the following features are being enforced for treasury operations:

(a) Verification of each payment request with physical bill without fail before putting the digital signature by Pay &Accounts Offices (PAOs).

(b) Use of NIC/GOV domain e-mail IDs for user registration by the officials dealing with PAO and DDO module of PFMS.

(c) Immediate deactivation of user(s) found to be no longer active

(d) Deactivation of user ID /Digital key of PAO/ AAO user type at the time permanent transfer/ superannuation).

(e) Use of NIC/GOV domain e-mail IDs for user registration by the officials dealing with PAO and DDO module of PFMS.

(f) Implementation of OTP based log in system on PFMS in phased manner.

(II) Implementation of electronic Bill (e-Bill) System of Public Financial Management System (PFMS)

In pursuance of the Digital India Initiative of Hon'ble Prime Minister, it was decided to develop a system to enable end to end digital processing of bills and claims from vendors, suppliers, contractors and all other typ es of payees of Government. The system was developed in the PFMS for the use in all Civil Ministries and Departments. With the initiative of e-bill, the complete payment system has become paperless.

- End-to-End electronic processing of claim and bill through PMFS on pilot-roll out of electronic Bill (e-Bill) system has been introduced in Department of Agricultural Research and Education w.e.f. 1 June 2022.

APPENDIX 3

LIST OF THE MEMBERS OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

4(i) Minister-in-charge of the portfolio of Agriculture and Farmers Welfare in the Union Cabinet-President of the Society.

President

1. Shri Narendra Singh Tomar — Ex-officio
Minister of Agriculture and Farmers Welfare, Government of India,
Krishi Bhavan, New Delhi-110 001

4(ii) Minister of State in the Union Ministry of Agriculture and Farmers Welfare dealing with ICAR- Vice President of the Society

Vice President

2. Shri Kailash Choudhary — Ex-officio
Minister of State for Agriculture and Farmers Welfare, Government of India,
Krishi Bhavan, New Delhi-110 001

4(iii) Union Ministers holding charge of Finance, Planning, Science and 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 Rao Inderjit Singh — Ex-officio
Minister of State (IC) for Planning, Statistics and Programme Implementation and MoS of Corporate Affairs,
Government of India, Room No. 132, NITI Aayog, New Delhi 110001

5. Dr. Jitendra Singh — Ex-officio
Minister of State (IC) for Science and Technology and Earth Sciences, Government of India,
CSIR Building, 2 Rafi Marg,
New Delhi-110 001

6. Shri Dharmendra Pradhan — Ex-officio
Minister of Education, Skill Development and Entrepreneurship
Government of India,
Shastri Bhavan, New Delhi-110 001

7. Shri Piyush Goyal — Ex-officio
Minister of Commerce and Industry, Government of India,
Udyog Bhavan, New Delhi-110 001

4(iv) Other Ministers in the Union Ministry of Agriculture and Farmers Welfare.

8. Sushri Shobha Karandlaje — Ex-officio
Minister of State for Agriculture and 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 and Dairying

** Union Minister of Fisheries, Animal Husbandry and Dairying will be the Senior Vice-President.*

Senior Vice-President

9. Shri Parshottam Rupala — Ex-officio
Minister of Fisheries, Animal Husbandry and Dairying, Government of India,
Krishi Bhavan, New Delhi-110 001

10. Shri Sanjeev Kumar Balyan — Ex-officio
Minister of State for Fisheries, Animal Husbandry and Dairying, Government of India,
Krishi Bhavan, New Delhi-110 001

11. Dr. L. Murugan
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 Kakani Govardhana Reddy — Ex-officio
Minister for Agriculture and Cooperation,
Government of Andhra Pradesh, A.P. Secretariat, Valagapudi, Hyderabad,
Andhra Pradesh-500 022

13 Dr. Seediri Appalaraju — Ex-officio
Minister for Animal Husbandry and Fisheries, Government of Andhra Pradesh, A.P. Secretariat, Valagapudi,
Hyderabad, Andhra Pradesh-500 022

ARUNACHAL PRADESH

14. Shri Tage Taki — Ex-officio
Minister for Agriculture, Animal Husbandry, Horticulture and Fisheries, Government of Arunachal Pradesh
CM Secretariat, Itanagar,
Arunachal Pradesh-791 111

ASSAM

15. Shri Atul Bora — Ex-officio
Minister for Agriculture and Horticulture and Animal Husbandry
Government of Assam,
Assam (Civil) Secretariat, Dispur,
Guwahati -781006, Assam

16. Shri Parimal Suklabaiya — Ex-officio
Minister of Fisheries,
Government of Assam,
Assam (Civil) Secretariat, Dispur,
Guwahati -781006, Assam

BIHAR

17. Sh. Kumar Sarvjeet — Ex-officio
Minister for Agriculture
Government of Bihar,
Vikas Bhavan, New Secretariat,
Bailey Road, Patna, Bihar-800 015

18. Md. Afaque Alam — Ex-officio
Minister of Animal Husbandry and Fisheries, Government of Bihar, Vikas Bhavan, New Secretariat, Bailey Road, Patna, Bihar-800 015

CHHATISGARH

19. Shri Ravindra Choubey — Ex-officio
Minister of Agriculture, Animal Husbadry and Fisheries, Government of Chhattisgarh, Mahanadi Bhawan, Mantralaya Naya Raipur - 492 002, Chhattisgarh

DELHI

20. Shri Gopal Rai — Ex-officio
Minister for Development Delhi Secretariat, I.P. Estate, New Delhi-110 002

GOA

21. Shri Ravi Naik — Ex-officio
Minister of Agriculture and Horticulture, Government of Goa, Secretariat, Porvorim, Goa-403 521

22. Sh. Nilkanth Halarnkar — Ex-officio
Minister of Animal husbandry and Fisheries, Government of Goa, Secretariat, Porvorim, Goa-403 521

GUJARAT

23. Shri Raghavjibhai Hansrajbhai Patel — Ex-officio
Minister for Agriculture, Animal Husbandry and Fisheries, Government of Gujarat, Swarnim Sankul-I, 2nd Floor, Sachivalaya Sector-10, Gandhinagar, Gujarat-382 010

HARYANA

24. Shri Jai Prakash Dalal — Ex-officio
Minister for Agriculture and Farmers Welfare, Horticulture, Animal Husbandry and Fisheries, Government of Haryana, Haryana Civil Secretariat, Chandigarh, Haryana - 160 001

HIMACHAL PRADESH

25. Shri Chander Kumar — Ex-officio
Minister for Agriculture & Animal Husbandry, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002

26. Shri Jagat Singh Negi — Ex-officio
Minister for Horticulture, Government of Himachal Pradesh, H.P. Secretariat, Shimla, Himachal Pradesh-171 002

JHARKHAND

27. Shri Badal Patralekh — Ex-officio
Minister of Agriculture, Animal Husbandry, Government of Jharkhand, Project Building HEC, Dhurva, Ranchi, Jharkhand-834 002

KARNATAKA

28. Sh. B. C. Patil — Ex-officio
Minister for Agriculture, Government of Karnataka, Vidhan Soudha, Bengaluru, Karnataka-560 001

29. Sh. N. Muniratna — Ex-officio
Minister for Horticulture, Government of Karnataka, Vidhan Soudha, Bengaluru, Karnataka-560 001

30. Shri Prabhu Chauhan — Ex-officio
Minister of Animal Husbandry, Government of Karnataka, Vikasa Soudha, Bangaluru, Karnataka-560 001

31. Sh. S. Angara — Ex-officio
Minister of Fisheries, Government of Karnataka, Vikasa Soudha, Bangaluru, Karnataka-560 001

KERALA

32. Shri Sri. P. Prasad — Ex-officio
Minister for Agriculture, Government of Kerala, Government Secretariat Annexe Thiruvananthapuram, Kerala-695 001

33. Smt. J. Chinchurani — Ex-officio
Minister for Animal Husbandry Government of Kerala Government Secretariat Annexe Thiruvananthapuram, Kerala-695 001

34. Shri. V. Abdhurahiman — Ex-officio
Minister for Fisheries, Government of Kerala, Government Secretariat Annexe, Thiruvananthapuram, Kerala-695 001

MADHYA PRADESH

35. Shri Kamal Patel — Ex-officio
Minister of Agriculture Development, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006

36. Sh. Prem Singh Patel — Ex-officio
Minister of Animal Husbandry, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006

37. Shri Tulsi Silawat — Ex-officio
Minister of Fisheries Welfare and Fisheries Development, Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006

38. Shri Bharat Singh Kushwaha — Ex-officio
(MoS independent charge)
Minister of State for Horticulture Government of Madhya Pradesh, Vallabh Bhavan, Bhopal, Madhya Pradesh-423 006

MAHARASHTRA

39. Shri Abdul Sattar — Ex-officio
Minister for Agriculture Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

40. Sh. Sandipan Bhumre — Ex-officio
Minister for Horticulture, Government of Maharashtra, Mantralaya, Mumbai, Maharashtra-400 032

41. Sh. Radhakrishna Vikhe Patil — Ex-officio
Minister for Animal Husbandry Government of Maharashtra, Mantralaya, Mumbai,

Maharashtra-400 032

42. Shri Sudhir Mungantiwar — Ex-officio
Minister for Fisheries
Government of Maharashtra,
Mantralaya, Mumbai,
Maharashtra-400 032

MANIPUR

43. Shri Thongam Biswajit Singh — Ex-officio
Minister for Agriculture,
Government of Manipur,
Room No. 120, North Block Secretariat,
Imphal, Manipur-795 001

44. Sh. Letpao Haokip — Ex-officio
Minister for Horticulture,
Government of Manipur, Room No. 214,
South Block, Manipur Secretariat,
Imphal, Manipur-795 001

45. Shri Heikham Dingo Singh — Ex-officio
Minister for Fisheries
Government of Manipur, Room No. 316-318,
3rd Floor, Western Block, New Secretariat,
Imphal, Manipur-795 001

MEGHALAYA

46. Sh. Banteidor Lyngdoh — Ex-officio
Ministry of Agriculture and Horticulture
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya-793 001

47. Sh. Sanbor Shullai — Ex-officio
Minister for Animal Husbandry
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya-793 001

48. Sh. Sniawbhalang Dhar — Ex-officio
Minister for Fisheries
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong, Meghalaya-793 001

MIZORAM

49. Shri Zoramthanga — Ex-officio
Hon'ble Chief Minister and holding the
charge of Ministry of Horticulture
Government of Mizoram,
Aizwal, Mizoram - 796 001

50. Er. Lalrinawma — Ex-officio
Ministry, Animal Husbandry,
Government of Mizoram,
Aizwal, Mizoram - 796 001

51. Shri C. Lalrinsanga — Ex-officio
Minister of State (IC)
for Agriculture,
Government of Mizoram,
Aizwal, Mizoram - 796 001

52. Shri K. Lalrinliana — Ex-officio
Minister of State (IC)
for Fisheries,
Government of Mizoram,
Aizwal, Mizoram - 796 001

NAGALAND

53. Sh. Neiphiu Rio — Ex-officio
Chief Minister holding the charge of
Ministry of Horticulture, Animal husbandry and Fisheries,
Government of Nagaland,
Civil Secretariat Complex
Kohima, Nagaland-797 004

54. Shri G. Kaito Aye — Ex-officio
Minister of Agriculture,
Government of Nagaland,
Civil Secretariat Complex
Kohima, Nagaland-797 004

ODISHA

55. Shri Ranendra Pratap Swain — Ex-officio
Minister for Agriculture, Fisheries and
Animal Resource Development,
Government of Odisha,
Odisha Secretariat,
Bhubaneswar, Odisha-751 001

PUNJAB

56. Shri Chetan Singh Jauramajra — Ex-officio
Minister of Horticulture,
Government of Punjab,
Punjab Civil Secretariat,
Chandigarh, Punjab

57. Shri Kuldeep Singh Dhaliwal — Ex-officio
Minister for Agriculture and Farmers Welfare,
Government of Punjab,Punjab Civil Secretariat,
Chandigarh, Punjab

58. Shri S. Laljit Singh Bhullar — Ex-officio
Minister for Animal husbandry and Fisheries, Government
of Punjab,
Punjab Civil Secretariat,
Chandigarh, Punjab

PUDUCHERRY

59. Shri. C. Djeacoumar — Ex-officio
Minister of Agriculture and Animal Husbandry,
Government of Puducherry,
Puducherry-605 001

60. Shri. K. Lakshminarayanan — Ex-officio
Minister for Fisheries
Government of Puducherry,
Puducherry-605 001

RAJASTHAN

61. Shri Lal Chand Kataria — Ex-officio
Minister for Agriculture, Animal Husbandry and Fisheries,
Government of Rajasthan,
Rajasthan Secretariat,
Mantralaya Bhawan,
Jaipur, Rajasthan - 302 005

SIKKIM

62. Shri Lok Nath Sharma — Ex-officio
Minister for Agriculture Development and Horticulture,
Animal Husbandry, Government of Sikkim,
New Secretariat, Development Area,
Gangtok,
Sikkim-737 101

TAMIL NADU

63. Shri Thiru M.R.K. Panneerselvam — Ex-officio
Minister for Agriculture and Horticulture
Government of Tamil Nadu,
Chennai, Tamil Nadu-600 009

64 Shri Thiru Anitha R. Radhakrishnan — Ex-officio
Minister for Fisheries and Animal Husbandry, Government
of Tamil Nadu, Chennai,
Tamil Nadu-600 009

TELANGANA

65 Shri Singireddy Niranjan Reddy — Ex-officio
Minister of Agriculture
Government of Telangana,
Haka Bhawan, 2nd Floor, Nampally,
Telangana Secretariat
Hyderabad - 500 004, Telangana

66 Shri Talasani Srinivas Yadav — Ex-officio
Minister of Animal husbandry and Fisheries,
Government of Telangana,
Room No.261, D-Block, Telangana Secretariat,
Hyderabad - 500 022, Telangana

TRIPURA

67 Shri Pranajit Singha Roy — Ex-officio
Minister for Agriculture,
Government of Tripura,
Civil Secretariat,
Agartala, Tripura-799 001

68 Shri Prem Kumar Reang — Ex-officio
Minister for Fisheries
Government of Tripura,
Civil Secretariat, Agartala,
Tripura-799 010

69 Smt. Bhagaban Ch. Das — Ex-officio
Minister for Animal Resource Development,
Government of Tripura, Civil Secretariat,
Agartala,
Tripura-799 001

UTTARAKHAND

70 Shri Ganesh Joshi — Ex-officio
Minister for Agriculture and Horticulture
Government of Uttarakhand,
Uttarakhand Vidhan Sabha Bhawan,
Dehradun, Uttarakhand

71 Sh. Saurabh Bahuguna — Ex-officio
Minister for Animal Husbandry and Fisheries,
Government of Uttarakhand,
Uttarakhand Vidhan Sabha Bhawan,
Dehradun, Uttarakhand

UTTAR PRADESH

72 Shri Surya Pratap Shahi — Ex-officio
Minister of Agriculture
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow, Uttar Pradesh

73 Shri Dharampal Singh — Ex-officio
Minister of Animal Husbandry,
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow, Uttar Pradesh

74 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

75 Sh. Dinesh Pratap Singh — Ex-officio
Minister of State for Horticulture
(Independent Charge)
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow, Uttar Pradesh

WEST BENGAL

76 Shri Sobhandeb Chattopadhyay — Ex-officio
Minister for Agriculture,
Government of West Bengal,
"NABANNA", HRBC Building,
3rd Floor, 325, Sarat Chatterjee Road,
Howrah – 711 102, Kolkata, West Bengal

77 Shri Swapan Debnath — Ex-officio
Minister of Animal Resources Development
Government of West Bengal,
Prani Sampad Bhavan,
LB-2, Sector-III, Salt Lake,
Kolkata – 700 106, West Bengal

78 Shri Akhil Giri — Ex-officio
Minister of State (IC) for Fisheries,
Government of West Bengal,
BENFISH TOWER, 8th Floor, GN Block, Salt Lake,
Sector-V, Kolkata – 700 091, West Bengal

79 Shri Subrata Saha — Ex-officio
Minister of state (IC) for Horticulture
Government of West Bengal,
Benfish Tower, 4th Floor, G. N. Block, Sector V,
Salt Lake City, Kolkata – 700 092, West Bengal

4(vii) Member, NITI Ayog, In-charge of Agriculture.

80 Prof. Ramesh Chand — Ex-officio
Member (Agriculture)
NITI Ayog,
Niti Bhawan, New Delhi-110 001

4(viii) Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha.

81 VACANT (due to office of profit)

82 VACANT -do-

83 VACANT -do-

84 VACANT -do-

85 VACANT -do-

86 VACANT -do-

4(ix) Director-General, Indian Council of Agricultural Research.

87 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 and Farmers Welfare.

88 Shri Manoj Ahuja — Ex-officio
Secretary, Department of Agriculture & Farmers Welfare,
Ministry of Agriculture and Farmers Welfare,
Krishi Bhavan, New Delhi-110 001

4(xi) All Secretaries in the Ministry of Fisheries, Animal Husbandry and Dairying.

89 Shri Jatindra Nath Swain, — Ex-officio
Secretary, Department of Fisheries,
Ministery of Fisheries, Animal Husbandry and Dairying,
Government of India, Krishi Bhavan,
New Delhi-110 001

90 Shri Rajesh Kumar Singh — 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

91 Shri Parameswaran Iyer — Ex-officio
CEO, Niti Ayog, Yojana Bhavan, Sansad Marg, New Delhi-110 001

4(xiii) Secretary, Department of Bio-Technology.

92 Dr. Rajesh S. Gokhale Secretary, — Ex-officio
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.

93 Dr. N Kalai Selvi — 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.

94 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)

95 Sh. Kamlesh Nilkanth Vyas — Ex-officio
Chairman, Atomic Energy Commission
Department of Atomic Energy,
Anushakti Bhavan,
Chhatrapati Shivaji Maharaj Marg,
Mumbai-400 001, Maharashtra

4(xvii) Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India.

96 Dr. T. V. Somanathan — Ex-officio
Secretary (Expenditure)
Department of Expenditure,
Ministry of Finance, North Block
New Delhi-110 001

97 *Alternative Member for Ministry of Finance - AS & FA (DARE/ICAR)*
Ms. Alka Nangia Arora — Ex-officio
JS & FA (DARE/ICAR), Krishi Bhawan,
New Delhi – 110001

4(xviii) Five Vice-Chancellors of Agricultural Universities, nominated by the President.

98 Prof S. K. Rao, — 17.05.2023
Vice Chancellor, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,
Race Course Road, Gwalior,
Madhya Pradesh-474 002

99 Dr. Anupam Mishra — 29.12.2023
Vice Chancellor, Central Agricultural University, Imphal,
P. O. Box No. 23,
Imphal-795004, Manipur

100 Dr. Rajeshwar Singh Chandel — 05.06.2025
Vice Chancellor, Dr. Y. S. Parmar University of Horticulture and Forestry,
Solan, Nauni-173230, Himachal Pradesh

101 Dr. D. R. Singh, — 11.07.2025
Vice Chancellor, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur,
Utter Pradesh

102 Dr. P.S Pandey — 29.9.2025
Vice Chancellor, Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar-848 -125

4(xix) Five technical representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner and Fisheries Development Commissioner from Union Ministries of Agriculture and Farmers Welfare/Fisheries, Animal Husbandry and Dairying and Inspector-General of Forests, Government of India.

103 Dr. P. K. Singh — Ex-officio
Agriculture Commissioner,
Deptartment of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi-110 001

104 Dr. Prabhat Kumar — Ex-officio
Horticulture Commissioner,
Dept. of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi-110 001

105 Dr. Abhijit Mitra — Ex-officio
Animal Husbandry Commissioner,
Depart,emt of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry & Dairying, Chander Lok Building, Janpath, New Delhi-110 001

106 Dr. Shankar Laxman — Ex-officio
Fisheries Development Commissioner
Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Krishi Bhavan,
New Delhi-110 001

107 Sh. Prem Kumar Jha — Ex-officio
Inspector General of Forests (NAEB)
Ministry of Environment and 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.

108 Dr. G. Kumaraswamy — 11.11.2024
H. No. 7-42/25, Saraswathi Colony, Street no. 4A, Bapuji Nagar, Nacharam- 500076,
Hyderabad, Telangana

109 Dr. A. Veerabhadra Rao — 11.11.2024
12-13-483/39/1, Tarnaka,
Street No 14, Lane 6,
Hyderabad-500 017, Telangana

110 Dr. Bagwan Naimoddin — 11.11.2024
Dr. N.B. Bagwan, 98-H, Sanjari Park-2 & 3, Nr. GEB Colony, Pethapur-382610, Gandhinagar,
(Gujarat)

111 Dr. Swadhinta Krishna — 11.11.2024
V-5 Osho Universe, Vinayak Puram, Sector-12, Vikas Nagar, Lucknow, Uttar Pradesh
Pin Code-226022

112 Dr. Rajendra Prasad — 11.11.2024
Professor,
Department of Horticulture
Kulbhaskar Ashram P.G. College,
4/4 C Muir Road, Near Anand Hospital,
Prayagraj -211 002, Uttar Pradesh

113 Dr. Nitai Charan Das 11.11.2024
Department of Soil and Water Conservation, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal - 741 252

114 Sh. Dinesh Patil 11.11.2024
Parth – Granth, ward no. 42, Subhash Nagar, Durg 491 001-Chhattisgarh

115 Dr. Yogesh A. Murkute 11.11.2024
PG Department of Geology,
RTM Nagpur University,
Law College Square,
Nagpur – 440 001, Maharashtra

116 Dr. Koushik Majumdar 11.11.2024
Centre for Bamboo Cultivation and Resources Utilization (BCRU), Department of Botany,
Tripura University, West Tripura,
Suryamaninagar-799022, Tripura

117 Dr. Arun Kumar Das 11.10.2025
Retd. Professor, & Head, OUAT,
Flat No. -4102, Terra Block, DNOXYPARK, Dumduma, PO Khandagiri, Bhubaneshwar-751019 Khurda-Odisha

118 Dr. Purushottam Ramniwas Zanwar 11.10.2025
Associate Professor
(Agricultural Entomology)
Department of Agricultural Entomology
College of Agriculture,
VNMKV, Parbhani-431402

119 Dr. Vinod Singh 11.10.2025
Department of Genetics and Plant Breeding,
A.N.D. University of Agriculture and Technology,
Kumarganj, Ayodhya-224 229, Uttar Pradesh

120 Dr. Rajendra Singh Rajput 11.10.2025
B-17/4, Vasant Vihar,
Ujjain, Madhya Pradesh

121 Dr. Maganti Sheshu Madhav 11.10.2025
Principal scientist- Biotechnology
ICAR-Indian Institute of Rice Research
Hyderabad, Telangana-500 030

Representative from the Indian Council of Medical Research

122 Dr. Bharati Kulkarni 01.11.2025
Scientist G & Head,
Division of Reproductive Biology,
Maternal and Child Health and 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.

123 VACANT

124 VACANT

125 VACANT

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.

126 **(Representative of Region- I)** 07.09.2023
Shri Nripendra Chaudhary
Village-Seemli, Ward No. – 2,
P.O. -Luxere, Distt. – Haridwar, Uttarakhand,- 247 663

127 **(Representative of Region- II)** 17.05.2023
Sh. Komirisetty Sambasiva Rao,
4-109, Pedapalakaluru (PO), Guntur Rural, Gunture District, Guntur – 522 005, Andhra Pradesh

128 **(Representative of Region- III)** 17.05.2023
Sh. Khangembam Nabakumar Singh,
Kumbi Bazar, P.S.-Kumbi, P.O.-Moirang, Bishnupur-District, Manipur – 795 133,

129 **(Representative of Region-IV)**
Sh. Sanjeev Kumar Yadav, 17.05.2023
State Vice-President, Bharatiy Janta Party Kisan Morcha, Jajak Toli Nai Sadak Chowk, Guru Govind Singh Path Chowk, Patna City, Patna – 800 008, Bihar

130 **(Representative of Region- V)**
Sh. Bikramjit Singh Cheema, 17.05.2023
Ward No. - 9, Payal, Ludhiana,
141416, Punjab

131 (Representative of Region- VI) 07.09.2023
Sh. Jagdish Singh
Village- Raidhana, Teh. – Ladnun,
Distt. - Nagaur, Rajasthan

132 **(Representative of Region- VII)** 17.05.2023
Sh. Manoj Bhaikaji Vyavahare,
AT/Post - Ashti, Tal. Mohol, Dist. Solapur,– 413 303, Maharashtra

133 **(Representative of Region- VIII)**
Sh. Virupaxi G. Revadigar 07.09.2023
Basava Medical Stores,
Basava Circle, Main Bazar,
Bilagi- 587116, Tq: Bilagi,
Dist: Bagalkot, Karnataka,

Four Representatives of Rural Interests, nominated by the President.

134 Sh. Umendra Dutt 21.11.2024
Kheti Virasat Mission,
R. V. Shanti Nagar, Jaitu - 151 202
Distt - Faridkot, Punjab

135 Sh. Manoj Bhai Purushottam Solanki 21.11.2024
Near Thakar Temple, Junavas Gram Panchayat Road, Madhapar (Tal. Bhuj), Kachchh – 370 020, Gujrat.

136 Sh. Ashok Kumar Tekam 21.11.2024
Doctor's Residence, Opposite District Copp. Bank, Girls College Road, Bhagat Singh Ward, Seoni
(Madhya Pradesh), - 480 661

137 Sh. Badri Narayan 21.11.2024
49- Gayatri Nagar-1, Tonk Road Sanganer, Jaipur, Rajasthan - 302 018

4(xxiii) Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President.

138 Dr. Amresh Chandra, 18.9.2025
Director, Indian Grassland and Fodder Research Institute (IGFRI), Jhansi – 284003, Uttar Pradesh.

139 Dr. Arun Kumar Tomar 07.12.2023/Term- 07.10.2025
Director, Central Sheep and Wool Research Institute (CSWRI), Avikanagar - 304501, Rajasthan

140 Dr. Triveni Dutt 16.03.2025 /Term - 30.09.2026
Director, ICAR-Indian Veterinary Research Institute,
Izatnagar, Bareilly,
Uttar Pradesh - 243122

141 Dr. R. A. Marathe 16.03.2025/Term- 27.04.2026
Director, National Research Center on Pomegranate, Solapur, NH-65, Solapur-Pune Highway, Kegaon, Solapur Maharastra - 413 255

4(xxiv) Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

142 Sh. M. Raghunandan Rao 17.06.2023/Ex-officio
Secretary,
Agriculture Cooperation Department,
Government of Telangana,
Ground Floor, D-block,
Fathe Maidan, Near Nizam College,
Basheer Bagh, Hyderabad,
Telangana – 500 001

143 Dr. Aboobacker Siddique 17.06.2023/Ex-officio
Secretary, Department of Agriculture, Animal Husbandry and Co-operatives,
Government of Jharkhand
Ground Floor, Nepal House,
Doranda, Ranchi – 834 002

144 Dr. Purna Chandra Kishan, IAS
Secretary, Department of Animal Husbandry, Fisheries and Gaupalan
Government of Rajasthan
Room No. 5008, Main Building,
Government Secretariat, Jaipur – 302 015

145 Sh. T. S. Jawahar 17.06.2023/Ex-officio
Additional Chief Secretary to Govt of Tamil Nadu, Animal Husbandry,
Dairying and Fisheries Department,
Secretariat,
Chennai – 600009, Tamil Nadu

4(xxv) One representative of Agro and Agro-Processing Industries, nominated by President

146 Sh. 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

147 Ms. Sushma Singh, 17.05.2023
MSA Flat No. 103,
Tower-1, Butler palace,
Lucknow – 226 001, Uttar Pradesh

4(xxvii) Secretary, Indian Council of Agricultural Research - Member Secretary

148 Shri Sanjay Garg Ex-Officio
Addl. Secy. (DARE) and Secy. (ICAR),
Krishi Bhavan, New Delhi-110 001

APPENDIX 4

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
   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. T. V. Somanathan — Ex-Officio
   Secretary(Expenditure), Department of Expenditure,
   129-A, North Block,
   Ministry of Finance,
   North Block, New Delhi-110 001

Alternate Mmember-Financial Adviser (DARE/ICAR)

Ms. Alka Nangia Arora, — Ex-Officio
Joint Secretary and 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. Parameswaran Iyer, — Ex-Officio
   CEO, Niti Ayog,
   Yojana Bhavan, Sansad Marg,
   New Delhi - 110 001

Rule 35(iv)
Secretary, Department of Agriculture Cooperation and Farmers Welfare

4. Shri Manoj Ahuja — Ex-Officio
   Secretary (Departmentof Agriculture and Farmers Welfare)
   Department of Agriculture and 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. Shri Rajesh Kumar Singh — Ex-Officio
   Secretary, Department of Animal Husbandry and Dairying, Ministry ofFisheries, Animal Husbandry
   Krishi Bhavan,
   New Delhi-110 001

Rule 35(vi)
Secretary, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying

6. Shri Jatindra Nath Swain, Secretary, — Ex-Officio
   Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Krishi Bhavan,
   New Delhi-110 001

Rule35(vii)
Three Scientists and one management expert from outside ICAR nominated by the President

7. Dr. Bagwan Naimoddin — 11.11.2024
   98-H, Sanjari Park-2&3, Nr. GEB Colony,
   Pethapur-382610, Gandhinagar (Gujarat)

8. Dr. Rajendra Prasad — 11.11.2024
   Professor
   Department of Horticulture
   Kulbhaskar Ashram P.G. College, 4/4 C Muir Road Near Anand Hospital Prayagraj -211002

9. Dr. Arun Kumar Das — 11.10.2025
   Retd. Prof. and Head
   Flat No.-4102, Terra Block,
   DNOXYPARK, Dumduma. P.O- Khandagiri,
   Bhubaneswar -751019, Dist.- Khurda. Odisha.

Rule 35 (viii)
Five Vice-Chancellors of Agricultural Universities (nominated by the President)

10. Dr. Anupam Mishra — 29.12.2023
    Vice Chancellor,
    Central Agricultural University, Imphal
    P. O. Box No. 23, Imphal-795004, Manipur

11. Prof S. K. Rao, — 17.05.2023
    Vice Chancellor,
    Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,
    Race Course Road, Gwalior,
    Madhya Pradesh-474 002

12. Dr Rajeshwar Singh Chandel — 05.06.2025
    Vice Chancellor
    Dr. Yashwant Singh Parmar
    University of Horticulture and
    Forestry Nauni, Solan, Himachal Pradesh
13. Dr. D. R. Singh — 11.07.2025
    Vice Chancellor
    Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208002, Uttar Pradesh

14. Dr. P. S. Pandey, — 29.09.2025
    Vice Chancellor, Dr. Rajendra Prasad
    Central Agricultural University,
    Samastipur-848125, Bihar

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. Sh. Bikramjit Singh Cheema, — 17.05.2023
    Ward No. - 9, Payal, Ludhiana,
    Pincode – 141416, Punjab

19. Sh. Jagdish Singh — 07.09.2023
    Village- Raidhana, Teh. – Ladnun,
    Distt. - Nagaur, Rajasthan
20. Shri Manoj Bhai Purushottam Solanki — 21.11.2024
    Near Thakar Temple, Junawas Gram

Panchayat Road, Madhapar (T. Bhuj),
Kutch – 370020, Gujrat

21. Shri Badri Narayan 21.11.2024
49- Gyatri Nagar-1, Tonk Road Sanganer,
Jaipur, Rajasthan - 302 018

Rule 35(xi)
Three Directors of Research Institutes of the Council nominated by the President

22. Dr Arun K. Tomar 07.12.2023
Director ICAR-Central Sheep & Wool Research Institute, Avikanagar (Malpura), 304 501
Disst.-Tonk, Rajasthan

23. Dr. Triveni Dutt Director, 15.3.2025
ICAR-Indian Veterinary Research Institute,
Bareilly, Utter Pradesh- 243 122

24. Dr. Amresh Chandra, Director, 18.09.2025
IGFRI- Indian Grassland & Fodder
Research Institute, Jhansi (UP) – 284 003

Rule 35(xii)
Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

25. Sri M. Raghunandan Rao, Secretary, 17.06.2023
Agriculture Cooperation Department,
Government of Telangana, Ground Floor,
D-Block, Fathe Maidan, Near Nizam College,
Basheer Bagh, Hyderabad,
Telangana – 500 001

26. Dr. Aboobacker Siddique 17.06.2023
Secretary, Department of Agriculture, Animal Husbandry and Co-operatives, Government of Jharkhand
Ground Floor, Nepal House, Doranda, Ranchi – 834 002

27. Shri Purna Chandra Kishan, IAS 17.06.2023
Secretary, Department of Animal Husbandry, Fisheries & Gaupalan
Government of Rajasthan
Room No. 508, Main Building, Government Secretariat
Jaipur – 302 015

28. Shri TS Jawahar, 17.06.2023
Additional Chief Secretary to Government of Tamil Nadu
Animal Husbandry, Dairying and Fisheries Department
Secretariat, Chennai - 600 009

Rule 35(xiii)
One representative of Agro and Agro-Processing Industries to be nominated by President

29. Sh. Kanwal Singh Chauhan, 13.09.2025
Village Aterna,
Distt. Sonipat-131 023, Haryana

Rule 35(xiv)
One representative from a distinguished Non-Governmental Organization dealing with Agriculture/ Extension nominated by President

30. Ms. Sushma Singh, 17.05.2023
MSA Flat No. 103,
Tower-1, Butler Palace,
Lucknow – 226001, Uttar Pradesh

Rule 35(xv)
Secretary, ICAR- Member Secretary

31. Sh. Sanjay Garg, Ex-Officio
Additional Secretary, DARE and Secretary, ICAR,
Krishi Bhawan, New Delhi- 110 001

APPENDIX 5

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 Directors General
1. Dr. Joykrushna Jena (Fisheries Science)
2. Dr. Anand Kumar Singh (Horticulture Science)
3. Dr. Suresh Kumar Chaudhari (Natural Resource Management)
4. Dr. Bhupender Nath Tripathi (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 Directors Generals
Crop Science
1. Dr. Ram Kewal Singh (CC)
2. Dr. Sanjeev Gupta (OP)
3. Dr. Devendra Kumar Yadava (Seed)
4. Dr. S.C. Dubey (PP&B)
5. Dr. Sharat Kumar Pradhan (FFC)

Horticultural Science
1. Dr. Vikramaditya Pandey (FPC Earlier HS-I) (Acting)

Natural Resource Management
1. Dr. S. Bhaskar (AAF&CC)
2. Dr. A. Velmurugan (S&WM)

Agricultural Engineering
1. Dr. Kairam Narsaiah (PE)
2. Dr. Panna Lal Singh (FE) (Acting)

Animal Science
1. Dr. Amrish Kumar Tyagi (AN&P)
2. Dr. Ashok Kumar (AH)
3. Dr. Pramod Kumar Rout (APB) (Acting)

Fisheries Science
1. Dr. Bimal Prasanna Mohanty (IF)
2. Dr. Prem Kumar (FE) (Acting)

Agricultural Extension
1. Dr. V.P. Chahal (AE) (Acting)
2. Dr. Sujeet Kumar Jha (AE) (Acting)

Agricultural Education
1. Dr. (Mrs.) Seema Jaggi, ADG(HRD)

Others Units
1. Dr. K. Srinivas (IPTM & PME) (Acting)
2. Dr. Navin Kumar Jain (HRM) (Acting)
3. Dr. Jai Prakash Mishra (IR) (Acting)
4. Dr. Anil Rai (ICT) (Acting)
5. Dr. Pawan Kumar Agrawal (TC)(Acting)

National Agricultural Science Fund (NASF)
1. Dr. Devendra Kumar Yadava, (NASF)(Additional charge)

Principal Scientists
Crop Science
1. Dr. S.K. Jha
2. Dr. P.R. Chaudhary
3. Dr. Renu
4. Dr. Ishwar Singh

Horticultural Science
1. Dr. Manish Das
2. Dr. Anup Kumar Bhattacharjee

Natural Resource Management
1. Dr. Adlul Islam
2. Dr. B.P. Bhatt

Agricultural Education
1. Dr. (Mrs.) Vanita Jain
2. Dr. (Mrs.) Nidhi Verma
3. Dr. Kanihiya Prasad Tripathi
4. Dr. Surender Kumar Sankhyan
5. Dr. Sita Ram Sharma
6. Dr. Dinesh Chand

Fisheries Science
1. Dr. (Mrs.) Yasmeen Basade

Agricultural Engineering
1. Dr. Devinder Dhingra
2. Dr. Abhay Kumar Thakur

Animal Sciences
1. Dr. (Mrs.) Jyoti Misri
2. Dr. Rajneesh Rana

Agricultural Extension
1. Dr. P. Adhiguru
2. Dr. Keshava

Others Units
1. Dr. Trilochan Mohapatra
2. Dr. Praveen Malik (DG Office)
3. Dr. Manoj Kumar Tripathi (PIM)
4. Dr. Basant Kumar Kandpal (PIM)
5. Dr. A.S. Mishra Technical Coordination
6. Dr. Sanjeev Panwar (Tech. Cdn.)
7. Dr. Shiv Datt (IPTM)
8. Dr. (Mrs.) Manju Gerard (IPTM)
9. Dr. Vikram Singh (IPTM)
10. Dr. Ashok Kumar (NASF)
11. Dr. A. K. Mishra (IR)
12. Dr. Krishan Pal Singh (ICT)
13. Dr. Himanshu (ICT)

National Agricultural Higher Education Project (NAHEP)

1. Dr. P. Ramasundaram, PS & NC
2. Dr. (Mrs) Hema Tripathi, PS & NC
3. Dr. Anuradha Agrawal, PS & NC
4. Dr. Sanjay Singh Rathore, PS & NC

Directorate of Knowledge Management in Agriculture

1. Dr. Suresh Kumar Malhotra, Project Director

APPENDIX 6

ICAR INSTITUTES AND THEIR DIRECTORS

1. Dr. Ashok Kumar Singh
   Indian Agricultural Research Institute,
   New Delhi 110 012
2. Dr. Triveni Dutt
   Indian Veterinary Research Institute,
   Izatnagar 243 122,
   Uttar Pradesh
3. Dr. Dheer Singh (Acing)
   National Dairy Research Institute,
   Karnal 132 001, Haryana
4. Dr. Ravishankar Chandragiri Nagarajarao
   Central Institute of Fisheries Education, Jaiprakash Road,
   Seven Bungalow (Versova)
   Mumbai 400 061, Maharashtra
5. Dr. Ch. Srinivasa Rao (Acting)
   National Academy of Agricultural Research Management,
   Rajendranagar,
   Hyderabad 500 030,
   Andhra Pradesh
6. Dr. Jagadish Rana (Acing)
   National Institute of Abiotic Stress Management,
   Malegaon, Baramati,
   Pune 413 115, Maharashtra
7. Dr. Arunava Pattanayak
   Indian Institute of Agricultural Biotechnology,
   Ranchi 834 010, Jharkhand
8. Dr. Probir Kumar Ghosh
   National Institute of Biotic Stress Management, Baronda,
   Raipur 493 225, Chhattisgarh.
9. Dr. Eaknath B. Chakurkar
   Central Island Agricultural Research Institute, Post Box
   No. 181 Port Blair 744 101, Andaman & Nicobar Islands
10. Dr. O.P. Yadav (Acting)
    Central Arid Zone Research Institute,
    Jodhpur 342 003, Rajasthan
11. Dr. Champat Raj Mehta
    Central Institute of Agricultural Engineering, Nabi Bagh
    Berasia Road, Bhopal 462 038, Madhya Pradesh
12. Dr. D. K. Samadia (Acting)
    Central Institute of Arid Horticulture,
    Bikaner 334 006, Rajasthan
13. Dr. YG Prasad
    Central Institute for Cotton Research
    Post Bag No. 2, Shankar Nagar P.O.
    Nagpur 440 010, Maharashtra
14. Dr. Devendra Kumar Pandey (Acting)
    Central Institute for Sub-tropical Horticulture,
    Rehmankhera, PO Kakori,
    Lucknow 227 107, Uttar Pradesh
15. Dr. Om Chand Sharma (Acting)
    Central Institute of Temperate Horticulture,
    Old Air Field, Rangreth 190 007,
    Jammu & Kashmir
16. Dr. Nachiket Kotwaliwale
    Central Institute of Post-Harvest Engineering and
    Technology, P.O. PAU Campus,
    Ludhiana 141 004, Punjab
17. Dr. Sujeet Kumar Shukla
    Central Institute for Research on Cotton Technology,
    Adenwala Road, Matunga,
    Mumbai 400 019, Maharashtra
18. Dr.K. Muralidharan (Acting)
    Central Plantation Crops Research Institute,
    Kasaragod 671 124, Kerala
19. Dr. Devendra Kumar (Acting)
    Central Potato Research Institute
    Shimla 171 001, Himachal Pradesh
20. Dr. Vinod Kumar Singh
    Central Research Institute for Dryland Agriculture,
    Santoshnagar, Saidabad P.O.,
    Hyderabad 500 059,Telangana
21. Dr. Dinesh Babu Shakyawar
    National Institute of Natural Fibre Engineering &
    Technology,
    12, Regent Park, Kolkata 700 040,
    West Bengal
22. Dr. Amresh Kumar Nayak
    National Rice Research Institute,
    Cuttack 753 006, Odisha.
23. Dr. Parbodh Chander
    Central Soil Salinity Research Institute,
    Zarifa Farm, Kachhwa Road,
    Karnal – 132 001, Haryana
24. Dr. M Madhu
    Indian Institute of Soil and Water Conservation,
    218, Kaulagarh Road,
    Dehradun 248 195, Uttarakhand
25. Dr. Maganti Sheshu Madhav
    Central Tobacco Research Institute,
    Rajahmundry 533 105, Andhra Pradesh
26. Dr. M N Sheela (Acting)
    Central Tuber Crops Research Institute,
    Sreekariyam,
    Thiruvananthapuram 695 017, Kerala
27. Dr. Parveen Kumar
    Central Coastal Agricultural Research Institute,
    Ela, old Goa, North Goa 403 402, Goa
28. Dr.A. Upadhayaya (Acting)
    ICAR Research Complex for Eastern Region, ICAR
    Parisar, P.O. Bihar Veterinary College,
    Patna 800 014, Bihar
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. Amaresh Chandra
    Indian Grassland and Fodder Research Institute,
    Pahuj Dam, Gwalior Road,
    Jhansi 284 003, Uttar Pradesh
32. Dr. Debi Sharma (Acting)
    Indian Institute of Horticultural Research
    Hessaraghatta Lake Post,
    Bengaluru 560 089, Karnataka
33. Dr. Bansa Singh (Acting)
    Indian Institute of Pulses Research,
    Kanpur 208 024, Uttar Pradesh
34. Dr. Amar Bahadur Singh (Acting)
    Indian Institute of Soil Sciences,
    Nabi Bagh, Berasia Road,
    Bhopal 462 038, Madhya Pradesh
35. Dr. C. K. Thankamani (Acting)
    Indian Institute of Spices Research, Marikunnu P.O.,
    Kozhikode 673 012, Kerala

36. Dr. Ashwini Dutt Pathak (Acting)
Indian Institute of Sugarcane Research,
Rai Bareilly Road, P.O. Dilkusha,
Lucknow 226 002, Uttar Pradesh
37. Dr. Abhijit Kar
National Institute of Natural Resins and Gums
Namkum, Ranchi 834 010, Jharkhand
38. Dr. Tusar Kanti Behera
Indian Institute of Vegetable Research, PB No. 01,
PO Jakhini, Shahanshapur
Varanasi 221 005, Uttar Pradesh
39. Dr. G Hema Prabha
Sugarcane Breeding Institute,
Coimbatore 641 007, Tamil Nadu
40. Dr. Lakshmi Kant
Vivekanand Parvatiya Krishi Anusandhan Sansthan,
Almora 263 601, Uttarakhand
41. Dr. Gouranga Kar
Central Research Institute for Jute & Allied Fibres,
Barrackpore, Kolkata 700120, West Bengal
42. Dr. Azad Singh Panwar
Indian Institute of Farming System Research,
Modipuram, Meerut 250 110, Uttar Pradesh
43. Dr. Sujay Rakshit (Acting)
Indian Institute of Maize Research,
PAU Campus, Ludhiana141004, Punjab
44. Dr. M.V. Prasad (Acting)
Indian Institute of Oil Palm Research,
Pedavegi 534 450, West Godavari, Andhra Pradesh
45. Dr. Ravi Kumar Mathur
Indian Institute of Oilseeds Research,Rajendranagar,
Hyderabad 500 030 Telangana
46. Dr. Raman Meenakshi Sundaram
Indian Institute of Rice Research,
Rajendranagar, Hyderabad 500 030, Telangana
47. Dr. Gyanendra Singh
Indian Institute for Wheat and Barley Research
P. Box No. 158, Agrasain Marg,
Karnal 132 001, Haryana
48. Dr. Rabindra Kumar Panda (Acting)
Indian Institute of Water Management, Opposite Rail
Vihar, Chandersekharpur
Bhubaneshwar 751 023, Odsha
49. Dr. Mridula Devi
Central Institute for Women in Agriculture,
Plot No.50, Mauza-Jokalandi,
P.O. Baramunda, Bhubaneswar 751 003 Odisha
50. Dr. Ayyandar Arunachalam
Central Agro-Forestry Research Institute,
Near Pahuj Dam,
Jhansi 284 003, Uttar Pradesh
51. Dr. Dilip Kumar Ghosh
Central Citrus Research Institute,
P.B. No. 464, Shankar Nagar P.O.,
Amravati Road, Nagpur 440 010, Maharashtra
52. Dr. Pratap Singh Birthal
National Institute of Agricultural Economics & Policy
Research, P.B. No. 11305, DPS Marg,
Pusa, New Delhi 110 012
53. Dr. Sanjay Kumar
Indian Institute of Seed Science
P.B. No. 11, Kusmaur, P.O. Kaithauli,
Mau Nath Bhanjan 275 101, Uttar Pradesh
54. Dr. C. V. Ratnavathi (Acting)
Indian Institute of Millets Research,
Rajendranagar,
Hyderabad 500 030 Telangana
55. Dr. Kunwar Harendra Singh
Indian Institute of Soybean Research, Khandwa Road,
Indore 452 017, Madhya Pradesh
56. Dr. Ajit Kumar Shasany
ICAR-NIPB (earlier NRCPB)
LBS Centre, Pusa Campus, New Delhi 110012
57. Dr. Subhash Chander
National Research Centre for
Integrated Pest Management,
LBS Building, New Delhi110 012
58. Dr. Krishna Gopal Mandal
Mahatma Gandhi Integrated Farming Research Institute,
Piprakothi, Motihari, East Champaran,
Bihar 845 429.
59. Dr. Ashok Kumar Tiwari
Central Avian Research Institute
Izatnagar, Bareilly 243 122,
Uttar Pradesh
60. Dr. Tirtha Kumar Datta
Central Institute for Research on Buffaloes, Sirsa Road,
Hissar 125 001, Haryana
61. Dr. Manish Kumar Chatli
Central Institute of Research on Goats, Makhdoom,
Mathura 281122, Uttar Pradesh
62. Dr. Basant Kumar Das
Central Inland Fisheries Research Institute,
Barrackpore 700 120, West Bengal
63. Dr. Kuldeep Kumar Lal
Central Institute of Brackishwater Aquaculture,
75, Santhome High Road,
Raja Annamalai Puram,
Chennai 600 028, Tamil Nadu
64. Dr. George Ninan
Central Institute of Fisheries Technology,
Willingdon Island, Matsyapuri P.O.,
Kochi 682 029, Kerala
65. Dr. Pramoda Kumar Sahoo
Central Institute of Freshwater Aquaculture,
Kausalyaganga, Bhubaneshwar,
Khurda 751 002, Odisha
66. Dr. A. Gopalakrishnan
Central Marine Fisheries Research Institute,
P.B. No. 1603, Ernakulam North P.O.,
Kochi 682 018, Kerala
67. Dr. Arun Kumar
Central Sheep and Wool Research Institute,
Avikanagar 304 501, Distt. Tonk, Rajasthan
68. Dr. Raghevendra Bhatta
National Institute of Animal Nutrition and Physiology,
Adugodi, Bengaluru 560 030
Karnataka
69. Dr. Aniket Sanyal
National Institute of High Security Animal Diseases, Anand
Nagar, Bhopal 462 021, Madhya Pradesh
70. Dr. Umesh Kumar (Acting)
Central Institute for Research on Cattle, P.B. No. 17,
Grass Farm Road, Meerut Cantt. 250 001 Uttar Pradesh
71. Dr. Vishal Nath
OSD, IARI, Jharkhand
72. Dr. Bibek Ranjan Shome
National Institute of Veterinary Epidemiology and
Disease Informatics,
H.A. Farm Post, Hebbal,
Bengaluru 560 024, Karnataka

APPENDIX 7

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 560 024,
   Karnataka

2. Dr. Alok Kumar Srivastava (Acting)
   National Bureau of Agriculturally Important Micro-organisms,
   P.B. No. 6, Kusmaur,
   Maunath Bhanjan 275 101
   Uttar Pradesh

3. Dr. Gyanendra Pratap Singh
   National Bureau of Plant Genetic Resources,
   Pusa Campus, New Delhi 110 012

4. Dr. B. P. Bhaskar (Acting)
   National Bureau of Soil Survey and Land Use Planning,
   Shankar Nagar P.O., Amravati Road, Nagpur 440 010,
   Maharashtra

5. Dr. Bishnu Prasad Mishra
   National Bureau of Animal Genetic Resources,
   P.B. No. 129,
   G.T. Road Bye Pass,
   Karnal 132 001, Haryana

6. Dr. Uttam Kumar Sarkar
   National Bureau of Fish Genetic Resources,
   Canal Ring Road, P.O. Dilkusha, Lucknow 226 002,
   Uttar Pradesh

APPENDIX 8

DIRECTORATES, PROJECT DIRECTORATES, AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTES AND THEIR DIRECTORS

1. Dr. Sandip Kumar Bera
   Directorate of Groundnut Research,
   Post Box No. 5, Ivnagar Road,
   Junagadh 362 001, Gujarat

2. Dr. Pramod Kumar Rai
   Directorate of Rapeseed - Mustard Research, Sewar,
   Bharatpur 321 303, Rajasthan

3. Dr. Janki Sharan Mishra
   Directorate of Weed Research,
   Maharajpur, Adhartal,
   Jabalpur 482 004, Madhya Pradesh

4. Dr. Raviprasad (Acting)
   Directorate of Cashew Research,
   Darbe, P.O. Puttur 574 202,
   Dakshina Kannada Karnataka.

5. Dr. K. V. Prasad (Acting)
   Directorate of Floriculture Research
   Pune, Maharashtra

6. Dr. Satyanshu Kumar (Acting)
   Directorate of Medicinal and Aromatic Plants Research,
   Boriavi, Anand 387 310, Gujarat

7. Dr. Ved Prakash Sharma (Acting)
   Directorate of Mushroom Research, Chambaghat,
   Solan 173 213, Himachal Pradesh

8. Dr. Vijay Mahajan (Acting)
   Directorate on Onion and Garlic Research,
   Rajgurunagar, Pune 410 505, Maharashtra

9. Dr. Rabindra Prasad Singh
   Directorate of Foot and Mouth Disease, IVRI Campus,
   Mukteshwar 263138, Uttarakhand

10. Dr. Rudra Nath Chatterjee
    Directorate of Poultry Research,
    Rajendranagar, Hyderabad-500 030,
    Andhra Pradesh

11. Dr. Pramod Kumar Pandey
    Directorate of Coldwater Fisheries Research, Anusandhan Bhawan, Industrial Area, Bhimtal 263 136, Uttarakhand

12. Dr. S.K. Malhotra
    Directorate of Knowledge Management in Agriculture
    Krishi Anusandhan Bhawan-1
    Pusa, New Delhi 110012

Agricultural Technology Application Research Institutes

13. Dr. Rajbir Singh (Acting)
    Agricultural Technology Application Research Institute,
    Zone-I, PAU Campus, Ludhiana 141004, Punjab

14. Dr. Subrata Kumar Roy (Acting)
    Agricultural Technology Application Research Institute,Zone-II,
    Bhumi Vihar, Block-GB,
    Sector-III, Salt Lake,
    Kolkata 700 097, West Bengal

15. Dr. A. K.Singha (Acting)
    Agricultural Technology Application Research Institute,
    Zone-III, TOP, Umroi Road, Barapani 793 103, Meghalaya

16. Dr. U S Gautam (Acting)
    Agricultural Technology Application Research Institute,
    Zone-IV,
    G.T. Road, Rawatpura, Near Vikas Bhawan,
    Kanpur-208002, Uttar Pradesh

17. Dr. J.V. Prasad (Acting)
    Agricultural Technology Application Research Institute,
    Zone-V, CRIDA Complex, Santoshnagar,
    Hyderabad 500 059, Andhra Pradesh

18. Dr. Sunil Kumar Singh
    Agricultural Technology Application Research Institute,
    Zone-VI, CAZRI Campus,
    Jodhpur - 342 003 Rajasthan

19. Dr. Shyam Ranjan Kumar Singh (Acting)
    Agricultural Technology Application Research Institute,
    Zone-VII, JNKVV Campus, Jabalpur 484 002
    Madhya Pradesh

20. Dr. V. Venkatasubramanian
    Agricultural Technology Application Research Institute,
    Zone-VIII,
    ICAR Transfer of Technology Project,
    MRS HA Farm Post, Hebbal,
    Bengaluru - 560 030, Karnataka

21. Dr. Anjani Kumar (Acting)
    Agricultural Technology Application Research Institute,
    CPRS Campus P.O,
    Sahay Nagar, Patna,
    Bihar 801 506

22. Dr. Lakhan Singh
    Agricultural Technology Application Research Institute,
    College of Agriculture Campus, Shivajinagar,
    Pune 411 005, Maharashtra

23. Dr. Rajesh Kumar (Acting)
    Agricultural Technology Application Research Institute,
    Banphool Nagar, Basisthpur, Guwahati,
    Assam 781 006

APPENDIX 9

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

1. Dr. (Mrs.) S. Uma (Acting)
   National Research Centre for Banana,
   Thogamalai Road, Thayanur Post,
   Thiruchirapalli 620 102, Tamil Nadu

2. Dr. R.G. Somkumar (Acting)
   National Research Centre for Grapes,
   P.B. No. 3, Manjri Farm Post,
   Solapur Road, Pune 412 307, Maharashtra

3. Dr. Vinod Kumar (Acting)
   National Research Centre for Litchi
   Mushahari Farm, Mushahari,
   Muzaffarpur 842 002, Bihar

4. Dr. Ram Pal (Acting)
   National Research Centre for Orchids, Pakyong,
   Gangtok 737 106 Sikkim

5. Dr. Rajiv Arvind Marathe
   National Research Centre on Pomegranate,
   NH-9, Byepass Road, Shelgi
   Sholapur 4130 06, Maharashtra

6. Dr. S N Saxena (Acting)
   National Research Centre on Seed Spices,
   Tabiji 305 206, Ajmer, Rajasthan

7. Dr. Artabandhu Sahoo
   National Research Centre on Camel
   Jorbeer, P.B. No. 07
   Bikaner 334 001, Rajasthan

8. Dr. Tarun Kumar Bhattacharya
   National Research Centre for Equines,
   Hissar 125 001, Haryana

9. Dr. Sukhadeo Baliram Barbuddhe
   National Research Centre on Meat,
   Chengicherla,
   P.B. No. 19, Uppal PO,
   Hyderabad 500 039, Telangana

10. Dr. Girish Patil S
    National Research Centre for Mithun, Jharnapani, P.O.
    Medziphema 797 106, Nagaland

11. Dr. Vivek Kumar Gupta
    National Research Centre on Pig,
    Rani, Guwahati 781 131,
    Assam

12. Dr. Mihir Sarkar
    National Research Centre on Yak,
    Dirang, West Kameng 790 101, Arunachal Pradesh

APPENDIX 10

ALL INDIA CO-ORDINATED RESEARCH PROJECTS AND NETWORK PROGRAMMES

AICRPs

1. AICRP on Micro and Secondary Nutrients & Pollutant Elements in Soils and Plants, Bhopal
2. AICRP on Soil Test Crop Response, Bhopal
3. AICRP on Long Term Fertilizer Experiments, Bhopal
4. AICRP on Salt Affected Soils and Use of Saline Water, Karnal
5. AICRP on Irrigation Water Management, Bhubaneshwar
6. AICRP Dryland Agriculture, Hyderabad
7. AICRP on Agrometeorology, Hyderabad
8. AICRP on Integrated Farming System, Modipuram
9. AICRP on Agroforestry, Jhansi
10. AICRP on Weed Management, Jabalpur
11. AICRP on Farm Implements and Machinery, Bhopal
12. AICRP on Ergonomics and Safety in Agriculture, Bhopal (ESA)
13. AICRP on Energy in Agriculture and Agro based Industries, Bhopal (EAAI)
14. AICRP on Animal Energy System, Bhopal (earlier UAE)
15. AICRP on Plasticulture Engineering and Technology, Ludhiana
16. AICRP on Post Harvest Engineering and Technology, Ludhiana
17. AICRP on Rice, Hyderabad
18. AICRP on Wheat and Barley, Karnal
19. AICRP on Maize, Ludhiana
20. AICRP Sorghum, Hyderabad
21. AICRP on Pearl Millets, Jodhpur
22. AICRP on Small Millets, Bangaluru
23. AICRP on Forage Crops and Utilization, Jhansi
24. AICRP on Chickpea, Kanpur
25. AICRP on MULLaRP, Kanpur
26. AICRP on Pigeon Pea, Kanpur
27. AICRP NSP (Crops), Mau
28. AICRP on Oilseed, Hyderabad
29. AICRP on Linseed, Kanpur
30. AICRP on Sesame and Niger, Jabalpur
31. AICRP on Groundnut, Junagarh
32. AICRP on Soybean, Indore
33. AICRP on Rapeseed and Mustard, Bharatpur
34. AICRP on Sugarcane, Lucknow
35. AICRP on Cotton, Coimbatore
36. AICRP on Nematodes in Cropping System, New Delhi
37. AICRP on Biocontrol of Crop Pests, Bengaluru
38. AICRP-Honeybees and Pollinators, New Delhi
39. AICRP Fruits (Tropical and Sub Tropical), Bengaluru
40. AICRP Potato, Shimla
41. AICRP Floriculture, Pune
42. AICRP Mushroom, Solan
43. AICRP Vegetables, Varanasi
44. AICRP Tuber Crops, Thiruvananthapuram
45. AICRP Palms, Kasaragod
46. AICRP on Cashew, Puttur
47. AICRP Arid Zone Fruits, Bikaner
48. AICRP Spices, Calicut
49. AICRP on Medicinal & Aromatic Plants, Anand
50. AICRP on Cattle, Meerut
51. AICRP on Goat Improvement, Makhdoom
52. AICRP on Nutritional and Physiological Intervention for Enhancing Reproductive Performance in Animal
53. AICRP on ADMAS, Bengaluru
54. AICRP on Foot and Mouth Disease, Mukteshwar
55. AICRP on Poultry, Hyderabad
56. AICRP on Pig, Guwahati
57. AICRP Home Science

NETWORK PROJECTS

1. AINP on Soil Biodiversity - Biofertilizer, Bhopal
2. Network Programme on Organic Farming, Modipuram
3. Network project on Engineering Intervention in Micro irrigation system for Improving Water Productivity
4. Network project on Processing and Value Addition of Natural Resins and Gums, Ranchi
5. Network Project on Conservation of Lac Insect Genetic Resources, Ranchi
6. All India Network Project (AINP) on Potential Crops, New Delhi
7. Application of Micro-organisms in Agriculture and Allied Sectors (AMAAS)
8. Network Project on Functional Genomics and Genetic Modification in Crops, NIPB, New Delhi
9. AINP on Arid Legumes, Kanpur
10. AINP on Tobacco, Rajamundry
11. AINP on Jute and Allied Fibres, Barrackpore
12. AINP on Soil Arthropod Pests, Durgapura, Rajasthan
13. AINP on Agricultural Acarology, NCIPM, New Delhi
14. AINP on Pesticides Residues, New Delhi
15. AINP on Vertebrate Pest Management, Jodhpur
16. Network O&G
17. Network Project on Buffalo Improvement, Hisar
18. Network on Sheep Improvement, Avikanagar
19. Network on Gastro Intestinal Parasitism, Izatnagar
20. Network Programme on Blue Tongue Disease, Izatnagar
21. All India Network Program on Neonatal Mortality in Farm Animals, Izatnagar
22. All India Network Program on Diagnostic Imaging and Management of Surgical Condition in Animals, Izatnagar
23. Network Project on Animal Genetic Resources, Karnal
24. AINP Mericulture
25. AINP on Fish health

APPENDIX 11

AGRICULTURAL UNIVERSITIES

State Agricultural Universities

1. Acharya N G Ranga Agricultural University, Guntur
2. Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya
3. Dr Y S R Horticultural University, Venkataramannagudem
4. Sri Venkateswara Veterinary University, Tirupati
5. Assam Agricultural University, Jorhat
6. Bihar Agricultural University, Sabour, Bhagalpur
7. Bihar Animal Sciences University, Patna
8. Indira Gandhi Krishi Vishwavidhyalaya, Raipur
9. DAU Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya, Anjora, Durg
10. Sardar Krushinagar Dantiwada Agricultural University, Dantiwada
11. Anand Agricultural University, Anand
12. Navsari Agricultural University, Navsari
13. Junagarh Agricultural University, Junagarh
14. Kamdhenu University, Amreli
15. Chaudhary Charan Singh Haryana Agricultural University, Hisar
16. Lala Lajpat Rai University of Veterinary & Animal Sciences, Hisar
17. Haryana State University of Horticultural Sciences, Karnal
18. Ch. Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur
19. Dr Yaswant Singh Parmar University of Horticulture & Forestry, Solan
20. Birsa Agricultural University, Ranchi
21. Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar
22. Sher-e-Kashmir University of Agricultural Sciences & Technology, Jammu
23. University of Agricultural Sciences, Bengaluru
24. Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar
25. University of Agricultural Sciences, Raichur
26. University of Agricultural Sciences, Dharwad
27. University of Horticultural Science, Bagalkot
28. University of Agriculture & Horticulture Sciences, Shivamogga
29. Kerala Agricultural University, Thrissur
30. Kerala University of Fisheries and Ocean Studies, Panangad, Kochi
31. Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala
32. Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior
33. Nanaji Deshmukh Pashu Chikitsa Vishwavidyalaya, Jabalpur
34. Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur
35. Dr. Balasahib Sawant Kokan Krishi Vidyapeeth, Dapoli
36. Maharashtra Animal & Fisheries Sciences University, Nagpur
37. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani
38. Mahatma Phule Krishi Vidyapeeth, Rahuri
39. Dr. Punjabrao Deshmukh Krishi Vishwa Vidyapeeth, Akola
40. Odisha University of Agriculture & Technology, Bhubaneswar
41. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana
42. Punjab Agricultural University, Ludhiana
43. Maharana Pratap University of Agriculture & Technology, Udaipur
44. Swami Keshwanand Rajasthan Agricultural University, Bikaner
45. Rajasthan University of Veterinary & Animal Sciences, Bikaner
46. S K N Agriculture University, Jobner
47. Agriculture University, Kota
48. Agriculture University, Jodhpur
49. Tamil Nadu Agricultural University, Coimbatore
50. Tamil Nadu Veterinary & Animal Sciences University, Chennai
51. Tamil Nadu Dr J Jayalalithaa Fisheries University, Nagapattinam
52. Sri Konda Laxman Telangana State Horticultural University, Hyderabad
53. Sri P V Narsimha Rao Telangana Veterinary University, Hyderabad
54. Professor Jayashankar Telangana State Agricultural University, Hyderabad
55. G.B. Pant University of Agriculture & Technology, Pantnagar
56. VCSG Uttarakhand University of Horticulture & Forestry, Bharsar
57. Chandra Shekhar Azad University of Agriculture & Technology, Kanpur
58. Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh
59. Pt. Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidhyalaya Evem Go Anusandhan Sansthan, Mathura
60. Banda University of Agricultural and Technology, Banda
61. Bidhan Chandra Krishi Vishwavidhyalaya, Mohanpur
62. West Bengal University of Animal & Fishery Sciences, Kolkata
63. Uttar Banga Krishi Vishwavidhyalaya, Cooch Behar

Central Agricultural Universities

64. Central Agricultural University, Imphal
65. Rani Laxami Bai Central Agricultural University, Jhansi
66. Dr R.P. Central Agricultural University, Pusa, Samstipur, Bihar

Deemed Universities

67. Indian Agricultural Research Institute, New Delhi
68. Central Institute of Fisheries Education, Mumbai
69. Indian Veterinary Research Institute, Bareilly
70. National Dairy Research Institute, Karnal

Central Universities with Agricultural Faculty

71. Aligarh Muslim University, Aligarh
72. Nagaland University, Medziphema
73. Banaras Hindu University, Varanasi
74. Vishwa Bharti, Sriniketan

APPENDIX 12

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

S. No	Name of the posts	Total Posts Sanctioned	Total Employees in position	SC Employees	% to Total employees	ST Employees	% to Total employees	OBC Employees	% to Total employees	PwD Employees	% to Total employees	EWS Employees	% to Total employees
1	**Scientific Posts**												
a	DR-Scientist	4451	3653	533	14.59	216	5.91	1052	28.8	28	0.77	0	0
b	DR-Senior Scientist	1295	863	60	6.95	15	1.74	111	12.86	0	0	0	0
c	DR-Principal Scientist (HoDs/ HoRS/PCs)	665	226	13	5.75	3	1.33	24	10.62	1	0.44	0	0
d	RMP Positions (DDGs/ ADGs/ PDDKMA/ Director/ Joint Director)	175	81	2	2.47	0	0	4	4.94	0	0	0	0
Total		**6586**	**4823**	**608**	**12.61**	**234**	**4.85**	**1191**	**24.69**	**29**	**0.6**	**0**	**0**
2	**Technical Posts**												
a	Category-I	3839	2335	471	20.17	266	11.39	506	21.67	27	1.16	0	0
b	Category-II	2730	1495	245	16.39	139	9.3	376	25.15	15	1	0	0
c	Category-III	744	338	34	10.06	48	14.2	82	24.26	1	0.3	4	1.18
Total		**7313**	**4168**	**750**	**17.99**	**453**	**10.87**	**964**	**23.13**	**43**	**1.03**	**4**	**0.1**
3	**Administrative Posts**												
a	Group-'A'	597	397	68	17.13	36	9.07	60	15.11	4	1.01	0	0
b	Group-'B'	3060	1655	279	16.86	118	7.13	257	15.53	28	1.69	0	0
c	Group-'C'	1251	850	168	19.76	78	9.18	239	28.12	11	1.29	0	0
Total		**4908**	**2902**	**515**	**17.75**	**232**	**7.99**	**556**	**19.16**	**43**	**1.48**	**0**	**0**
4	**Supporting Skilled staff**												
Total		**5536**	**3545**	**952**	**26.85**	**415**	**11.71**	**747**	**21.07**	**26**	**0.73**	**0**	**0**

APPENDIX 13

ICAR AWARDS

Award	Awardees
1. National Awards of Excellence for Agricultural Institutions	
1.1 Sardar Patel Outstanding ICAR Institution Award 2021	
Large Institute Category	ICAR- National Academy of Agricultural Research Management (NAARM), Rajendranagar, Hyderabad Telangana 500 030
Small Institute Category	i. Shared between ICAR- National Institute of Animal Nutrition and Physiology, Bengaluru ii. ICAR-Indian Institute of Spices Research, PB No. 1701, Marikunnu P.O. Kozhikode Kerala 673 012
Agricultural University Category	Tamil Nadu Agricultural University, Coimbatore Tamil Nadu 641 003,
1.2 Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2021	
Best AICRP	All India Coordinated Research Project on National Seeds Project, Mau
Best Centre	Shared Between i. JUNK, Jabalpur ii. TNAU, Coimbatore
1.3 Pandit Deen Dayal Upadhyay Krishi Vigyan Rashtriya Protshahan Puraskar 2021	
First Prize	Krishi Vigyan Kendra, Cooch Behar, Uttar Banga Krishi Vishwa Vidyalaya, Cooch Behar, West Bengal
Second Prize	KVK, Ramanagara, University of Agricultural Sciences, Bengaluru
Third Prize (shared)	i. KVK, Basti, Acharya Narendra Dev University of Agriculture and Technology, Uttar Pradesh ii. KVK, Gwalior, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Madhya Pradesh
2. National Awards for Excellence in Agricultural Research	
2.1 ICAR-Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2021	
Crop and Horticultural Sciences	i. Dr Ajoy Kumar Roy, Principal Scientist (Genetics) and Project Coordinator, AICRP on Forage Crops and Utilization, IGFRI, Jhansi ii. Dr Parbodh Chander Sharma, Principal Scientist (Crop Sciences) and Director, ICAR-CSSRI, Karnal
Natural Resource Management and Agricultural Engineering	i. Dr Ashok Kumar Patra, Director, Indian Institute of Soil Science Nabi Bagh, Berasia Road, Bhopal ii. Rajbir Singh, Director, ICAR-ATARI, Ludhiana
Animal & Fisheries Sciences	Dr Samit Kumar Nandi, Professor and Former Head, Department of Veterinary Surgery and Radiology, West Bengal University of Animal and Fishery Sciences, Kolkata
Social Sciences	i. Dr A R Rao, ADG (PIM), ICAR Hqrs, Krishi Bhawan, New Delhi ii. Dr Mahesh Chander, Principal and Scientist and Head, Division of Extension Education, IVRI, Izatnagar
2.2 Lal Bahadur Shastri Outstanding Young Scientist Award 2021	
Crop and Horticultural Sciences	Dr Koushik Chakraborty, Scientist (Senior Scale), ICAR-NRRI, Bidyadharpur, Cuttack Odisha
Natural Resource Management and Agricultural Engineering	Dr Rahul Tripathi, Senior Scientist, ICAR- National Rice Research Institute, Cuttack, Odisha
Animal & Fisheries Sciences	Dr Naresh L Selokar, Scientist, ICAR- NDRI, Karnal
Social Sciences	Dr Shivendra Kumar Srivastava, Scientist (Senior Scale), ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi
2.3 Jawaharlal Nehru Award for Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2021	
Crop Sciences and Horticulture	Dr Roshan Kumar Singh, National Institute of Plant Genome Research (NIPGR), Aruna Asaf Ali Marg, New Delhi
Animal Sciences and Fisheries	Dr (Ms) Anusree M, ICAR- Central Marine Fisheries Research Institute, Kochi, Kerala
Social Sciences	Dr Tanuj Misra, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh

Award	Awardees
2.4 Panjabrao Deshmukh Outstanding Women Scientist Award 2021	Shared between Dr Sushila Maan, Lala Lajpat Rai University of Veterinary and Animal Sciences, House No. 105, Police Line Area, Kaimeri Road, Hisar, Haryana Dr (Mrs) Kambham Madhavi Reddy, ICAR-Indian Institute of Horticultural Research, Bengaluru Dr Sonu Gandhi, Scientist-D, National Institute of Animal Biotechnology, Hyderabad Telangana
3. National Awards for Application of Agricultural Technologies	
3.1 Nanaji Deshmukh ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences 2021	Shared between i. Dr Gyanendra Pratap Singh, Director, ICAR- Indian Institute of Wheat and Barley Research, Karnal (Team Leader) Dr Gyanendra Singh, ICAR-IIWBR, Karnal Dr B S Tyagi, ICAR-IIWBR, Karnal Dr Amit Kumar Sharma, ICAR-IIWBR, Karnal Dr Hanif Khan, ICAR-IIWBR, Karnal Dr Satish Kumar, ICAR-IIWBR, Karnal Dr Chandra Nath Mishra, ICAR-IIWBR, Karnal Dr K Gopalareddy, ICAR-IIWBR, Karnal Dr S C Bhardwaj, ICAR-IIWBR Regional Station, Shimla Dr Sudheer Kumar, ICAR-IIWBR, Karnal Dr Arun Gupta, ICAR-IIWBR, Karnal Dr Mamrutha H M, ICAR-IIWBR, Karnal Dr R S Chhokar, ICAR-IIWBR, Karnal Dr Poonam Jasrotia, ICAR-IIWBR, Karnal Dr Sewa Ram, ICAR-IIWBR, Karnal Dr R Sendhil, ICAR-IIWBR, Karnal ii. Dr Ashok Kumar Singh, Director, ICAR-IARI, New Delhi (Team Leader) Dr Gopala Krishnan S, ICAR-IARI, New Delhi Dr M Nagarajan, ICAR-IARI, New Delhi Dr K K Vinod, ICAR-IARI, New Delhi Dr Prolay Kumar Bhowmick, ICAR-IARI, Delhi Dr Haritha Bollinedi, ICAR-IARI, New Delhi Dr Ranjitih Kumar, ICAR-IARI, New Delhi Dr Kalyan K Mondal,ICAR-IARI, New Delhi Dr Bishnu Maya Bashyal, ICAR-IARI, New Delhi Dr Prakash G, ICAR-IARI, New Delhi Dr Rakesh Seth, IARI Regional Station, Karnal Dr Chandu Singh Rathod, ICAR-IARI, New Delhi Prof Subhash Chander, ICAR-IARI, New Delhi Dr Dinesh Kumar, ICAR-IARI, New Delhi Dr Madan Pal, ICAR-IARI, New Delhi Dr N K Singh, Project Director, ICAR NIPB, New Delhi Dr T R Sharma, DDG (CS), ICAR, New Delhi Dr S V Amitha Charu Rama Mithra, ICAR NIPB, New Delhi
3.2 Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2021	Shared Between i. Dr Kadirvel Govindasamy, ICAR Research Complex for NEH Region, Meghalaya and Associates Dr Kishore Kumar Baruah, ICAR Research Complex for NEH Region, Meghalaya Dr Sourabh Deori, ICAR Research Complex for NEH Region, Meghalaya ii. Dr M S Malik, University Professor, Birsa Agricultural University, Ranchi, Jharkhand and Associates Dr Prabhat Kumar, NAHEP-CAAST, ICAR, New Delhi Dr Adyant Kumar, NAHEP-CAAST, ICAR, New Delhi
3.3 Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2021	Shared between Dr Parvender Sheoran, ICAR- Central Soil Salinity Research Institute, Karnal

Award	Awardees
	Dr Raj Kumar Singh Tomar, Rajmata Vijayaraje ScindiaKrishi Vhiwa Vidyayalay, Krishi Vigyan Kendra, Datia, Madhya Pradesh
3.4 Vasant Rao Naik Award for Outstanding Research and Application in Dryland Farming System 2021	
	Shared between i. Dr Rajiv Arvind Marathe ICAR-NRC on Pomegranate, Solapur, Maharashtra (Team Leader) Dr Jyotsana Sharma, ICAR-NRCP, Solapur Dr Nripendra Vikram Singh, ICAR-NRCP, Solapur Dr K Dhinesh Babu, ICAR- NRCP, Solapur Dr Ashis Maity, ICAR- NRCP, Solarpur Dr Nilesh Nivrutti Gaikwad, ICAR NRCP, Solarpur ii. Dr J V N S Prasad ICAR-CRIDA, Hyderabad, (Team Leader) Telangana Dr V K Singh, ICAR-CRIDA, Hyderabad, Telangana Dr U N Tank, KVK Mundra, Kutch, Gujarat Dr R K S Tomar, KVK, Datia, Gwalior, Madhya Pradesh Dr Lakhan Singh, ICAR-ATARI, Pune, Madhya Pradesh Dr S R K Singh, ICAR-ATARI, Jabalpur, Madhya Pradesh
4. National Awards for Innovations and Technology Development by Farmers	
4.1 N G Ranga Farmer Award for Diversified Agriculture 2021	
Shared between	i. Sh Sethpal Singh, Village Nandi , Post –Nandi Firojpur, Distric Saharanpur, Uttar Pradesh ii. Smt Padala Bhudevi, Hiramandalam Mandal, Srikakulam District, Andhra Pradesh
4.2 Jagjivan Ram Abhinav Kisan Puruskar/ Jagjivan Ram Innovative Farmer Award 2021	
	Sh Surendra Wana, Village- Bhairana, Post- Bichoon, Tehsil- Dudu, District- Jaipur, Rajasthan Sh Ravindra Manikrao Metkar, “Matosjri Krushi Farm” Mahasla Anjangaon Bari Road. Badnera, Amravati, Maharashtra Sh Mohammed Ameerbabu K, Karuvally House, Karinchapadi, Vattaloor P O, Malappuram District, Kerala
4.3 Haldhar Organic Farmer Award 2021	
	Shared between i. Manoj Purushottambhai Solanki, Near Thaakar Mandir, Junaavaas, Madhapar, Block: Bhuj, district: Kachchh, Gujarat-370 020 ii. Dr Mohammed Idris Ahmed Quadri, Bidar, Karnataka
4.4 Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar 2021	
	Sh Kundan Lal, Village Khanyari, Post Office Kandha, Tehsil Chichyot, District Mandi, Himachal Pradesh Sh Devajit Changmai, Village Mothadang, Sripani, District Dhemaji, Assam Shared between i. Sh. Suresh Vishwanath Patil, Budihal, Tal: Nipani, Dist: Belagavi ii. Smt Bindu Joseph, Randuplackal House, Avadukka Post, Peruvannamuzhi, Kozhikode, Kerala

Acronyms

ABI	: Agri-business Incubation
ACE	: Angiotensin Converting Enzyme
ACPs	: Anti-cancer peptides
ACR	: Agro climatic region
AgIn	: Agri-Innovate India Limited
AICRP	: All India Coordinated Research Project
AIs	: Artificial inseminations
ALS	: Alternaria leaf spot
ALV	: Avian leucosis virus
AMS	: Academic Management System
ANN	: Artificial neural network
APR	: Adult plant resistance
ARYA	: Attracting and Retaining Youth in Agriculture
ASF	: African Swine Fever
ASS	: Abiotic Stress Information System
ATICs	: Agricultural Technology Information Centres
BEP	: Break-even point
BPH	: Brown plant-hopper
CAAST	: Centres for Advanced Agricultural Sciences and Technology
CAM	: Crassulacean Acid Metabolism
CAUs	: Central Agricultural Universities
CCARI	: Central Coastal Agricultural Research Institute
CFLDs	: Cluster Frontline Demonstrations
CIWA	: Central Institute for Women in Agriculture
DARE	: Department of Agricultural Research and Education
DSp	: Diagnostic specificity
DST	: Drought and Salt Tolerance
DUs	: Deemed-to-be-Universities
FAW	: Fall armyworm
FLDs	: Frontline Demonstrations
GBS	: Genotyping by Sequencing
GWAS	: Genome-Wide association study
ICDK	: Immunochromatography dared chicken detection kit
ICT	: Information Communication and Technology
IDA	: International Depository Authority
IDP	: Institutional Development Plan
IEC	: Information Education and Communication
IFS	: Integrated Farming System
IG	: Innovation Grants
IGP	: Indo-Gangetic Plain
IMTA	: Integrated multi-trophic aquaculture
IOFS	: Integrated organic farming system
IPO	: Indian Patent Office
KSHAMTA	: Knowledge Systems and Homestead Agriculture Management in Tribal Areas
KVKs	: Krishi Vigyan Kendras
LAMP	: Loop-mediated Isothermal Amplification
M&AP	: Medicinal and Aromatic Plants
MAS	: Market assisted Selection
MCRV	: Mud Crab Rco Virus
MGMG	: Mera Gaon Mera Gaurav
MoA	: Memorandum of Agreement
MSSP	: Mega Sheep Seed Project
NAARM	: National Academy of Agricultural Research Management
NAE	: Niche Area of Excellence
NAHEP	: National Agricultural Higher Education Preject
NAIMCC	: National Agriculturally Important Microbial Culture Collection
NARES	: National Agricultural Research and Education System
NARI	: Nutri-sensitive Agricultural Resources and Innovations
NARS	: National Agricultural Research System
NASF	: National Agricultural Science Fund
NBAM	: National Bureau of Agriculturally Important Microorganisms
NBAIR	: National Bureau of Agricultural Insect Resources
NCBI	: National Centre for Biotechnology Information
NEH	: North Eastern Hill
NEP	: New Education Policy
NGRR	: National Genomic Resource Repository
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
QTL : Quantitative trait loci
RAS : Rearanlatony aguacultune System
RDF : Recommended dose of fertilizer
RILs : Recombinant inbred lines
RPA : Recombinase polymerase amplification
RS : Raffinase Synthare
RSM : Response surface methodology
SARATHI : System of Agri-information Resources Auto-transmission and Technology Hub Interface
SARS-CoV-2 : Severe acute respiratory syndrome coronavirus 2
SAUs : State Agricultural Universities
SDGs : Sustainable Development Goals
SMDs : Subject Matter Division
SSS : Skilled Support Staff
TL : Truthfully labelled
TLB : Turcicum leaf blight
TMIS : Training Management Information System
TPS : True Potato Seed
TSP : Tribal Sub-Plan
UAV : Unmanned aerial vehicle
WUE : Water Use Efficiency

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities

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- 3 Central Agricultural Universities
- 4 Deemed Universities
- 4 Central Universities having Faculty of Agriculture

भाकृअनुप
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