Azadi Ka Amrit Mahotsav

ANNUAL REPORT

2021-22

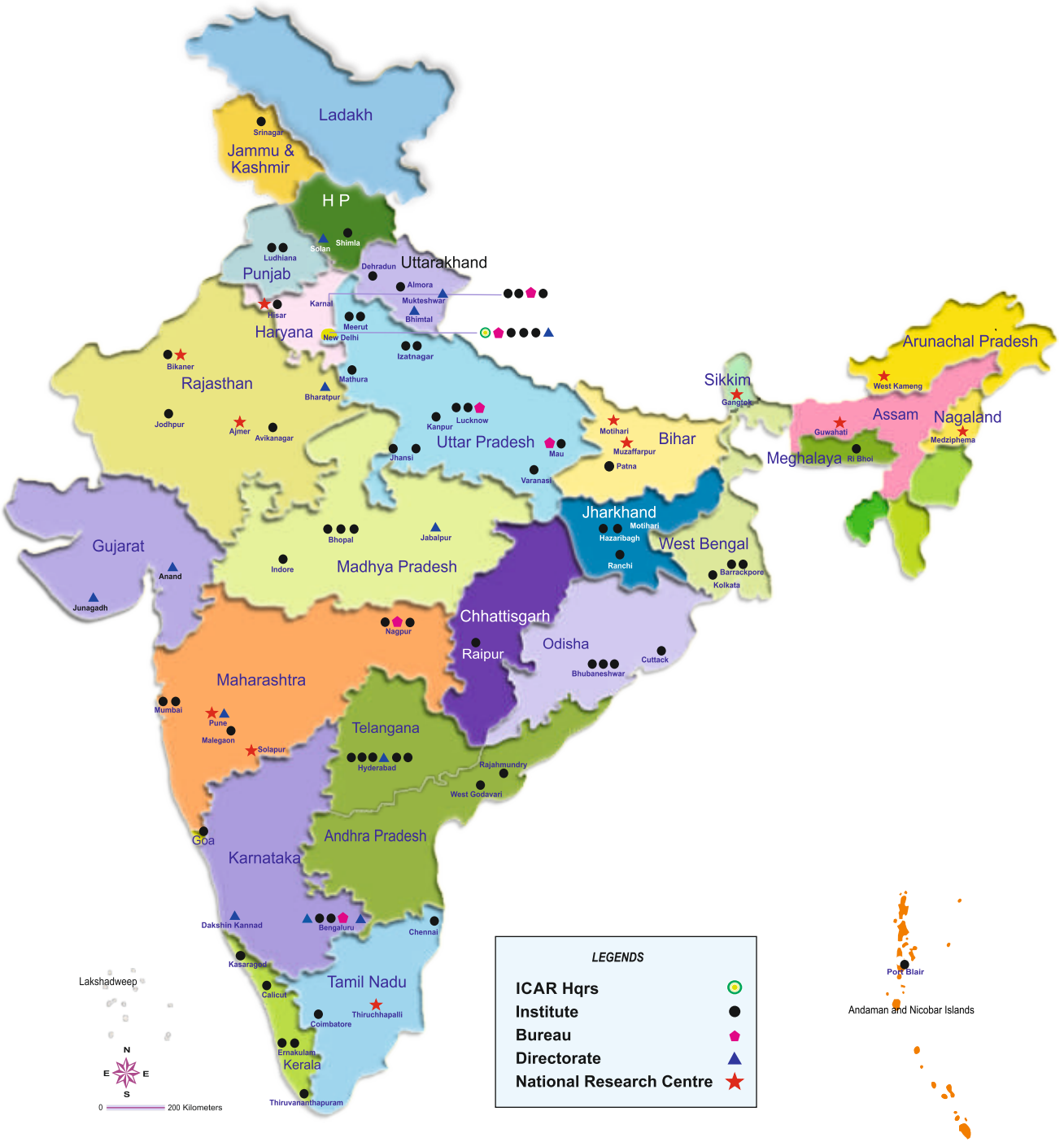
Indian Council of Agricultural Research
Department of Agricultural Research and Education
Ministry of Agriculture & Farmers Welfare
Government of India
New Delhi

सत्यमेव जयते

भाकृअनुप
ICAR

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, National Research Centres and Directorates



*Map not to the scale

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

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Foreword

Indian Agriculture has maintained a positive growth during Covid 19 pandemic, Department of Agricultural Research and Education (DARE) and Indian Council of Agricultural Research (ICAR) are part of this journey. We have tried to help thousands of farmers and other citizens affected during pandemic. We provided advisories for their health as well as farm management. The share of agriculture and related industries in GDP hit 20% after 17 years. We are helping next generation farmers by providing technologies for precision farming and climate resilient varieties for sustainable yield. Our journey has been appreciated by the Hon'ble Prime Minister and he has emphasized that science and technology have been used on a priority basis to solve the challenges related to agriculture during last 7 years. Hon'ble Prime Minister dedicated 35 crop varieties with special traits to address challenges of climate change and malnutrition. We need to further develop varieties and technologies to meet the challenges of climate change to restore agriculture and our ecosystem. For a healthy nation it is also necessary to create awareness by adopting nutritional food to fight with malnutrition. Our scientists, farmers and growers make every effort to produce safer food for a healthy India.

Plant germplasm included to National Genebank for long-term storage comprised 8,622 accessions of orthodox seed species and till date it has base collection of 4,56,568 accessions. Animal germplasm repository at National Gene Bank, ICAR-NBAGR, Karnal is being strengthened by preserving diversified form of germplasm. A total of 253 varieties/hybrids including 35 special traits varieties of crops were notified and released for commercial cultivations. Under the Indigenous Breeds Project (IBP), 6,500 Kankrej and 6,219 Gir cows were registered in the native tract. Four sets of Gir (33 bulls), Kankrej (35 bulls) and Sahiwal (35 bulls) were introduced out of which 22 bulls were evaluated for their genetic worth. In fisheries, picnic seabream or black seabream (*Acanthopagrus berda*) has high economic and recreational values, excellent meat quality and ability to tolerate wide variations in environmental conditions. Its breeding and seed production were achieved by induced breeding using salmon-GnRH-analogue hormone.

The important programmes such as Farmer FIRST, Attracting and Retaining Youth in Agriculture (ARYA), Cluster Frontline Demonstration of pulses and oilseeds, Cereal System Initiatives for South Asia (CSIA), National Innovations in Climate Resilient Agriculture (NICRA), Pulses Seed Hubs, *Mera Gaon Mera Gaurav* and Awareness creation of government schemes were undertaken to meet various challenges of engaging youth in Agriculture, bringing self-sufficiency in production of pulses and oilseeds, sustainable agriculture.

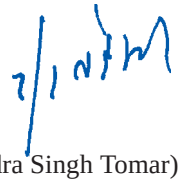
In all, 5 new KVKs were established taking the total number of KVKs to 729 in the country during the year. CSR GROW-SURE, a unique bio-stimulant consisting of highly efficient salt tolerant bacteria was developed. The ARYA project is operational in 100 KVKs. These KVKs organized 775 training programmes benefiting 16,812 youths. Nearly 32% trained rural youth established micro-entrepreneurial unit in rural areas which fetched them income ranging from ₹ 33,088 to ₹ 6,30,000/unit/annum across different entrepreneurial units. Technology Demonstration Component (TDC) of NICRA is being implemented through KVKs in 121 climate vulnerable districts of the country where in climate smart technologies for natural resource management, crops and livestock have been demonstrated along with institutional interventions.

Two multiple-stress tolerant rice varieties namely Swarna Samridhi Dhan and Swarna Sukha Dhan have been notified and released for cultivation in lowland ecosystem of Bihar and drought-prone upland ecology of Uttar Pradesh, respectively. Pusa-Farm Sun Fridge for storage of perishables was developed. An integrated organic farming system (IOFS) model (0.43 ha area) was developed at Umiam, Meghalaya to meet diverse requirement of the farm household while preserving the resource base and maintaining the ecology. The model has diversified farming components like field-crops (cereals, pulses, oilseeds), horticultural crops (Vegetables, fruits), livestock (one cow + calf), duckery (20 ducks) along with perennial fodder crops, composting units and central water harvesting pond for composite fish culture and as a source for irrigation during lean season. The potential microbial consortia 'Excel Decomposer' was developed for decomposition of different bio-waste. The 'Excel Decomposer' is being used for *in-situ* decomposition of rice and wheat residue in farmers' field of Bhopal.

The technological products like seeds and planting materials of improved varieties and hybrids, bio-products and improved species of livestock, poultry and fish were produced which benefited almost 16 lakh farmers

in the country. A total of 47 Agricultural Technology Information Centres (ATICs) are functioning as single window delivery system in the country and are serving very important purpose by providing technology information advisory services and technological inputs to the farmers. About 2.86 lakh farmers visit ATICs for obtaining solutions related to their agricultural problems and purchasing key farm inputs.

The ICAR is continuously making efforts to develop innovative technologies not only for sustainable agriculture but also climate smart technologies for mitigation of effects of climate change on agriculture. I hope that the *ICAR Annual Report 2021-22* will render help to all the stakeholders and for planning future strategies for agriculture research and education in the country.



(Narendra Singh Tomar)
President
ICAR Society

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Indian Council of Agricultural Research

President, ICAR Society, and Union Minister of Agriculture and Farmers Welfare	:	**Shri Narendra Singh Tomar**
Senior Vice President, ICAR Society, Union Minister of Fisheries, Animal Husbandry and Dairying	:	**Shri Parshottam Rupala (From 7 July, 2021)** **Shri Giriraj Singh (Till 6 July, 2021)**
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 (From 8 July, 2021)** **Shri Parshottam Rupala (Till 6 July, 2021)**
Union Minister of State for Fisheries, Animal Husbandry and Dairying	:	**Shri Sanjeev Kumar Balyan (From 7 July, 2021)** **Dr L Murugan (From 7 July, 2021)**
Secretary, DARE and Director General, ICAR	:	**Dr Trilochan Mohapatra**
Additional Secretary, DARE and Secretary, ICAR	:	**Shri Sanjay Garg (From 25 August, 2021)** **Shri Sanjay Singh (Till 30 June, 2021)**
Additional Secretary and Financial Adviser, DARE/ICAR	:	**Shri Sanjiv Kumar (From 1 September, 2021)**

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

I highlight the ICAR's accomplishments and progress towards achieving the Strategic Objectives, Key Performance Indicators (KPIs) and output outcome framework articulated during the year. ICAR ensures that groundbreaking discoveries and technologies to reach our farmers, producers and consumers. We at ICAR are working towards self-reliant agriculture, most customer-focused activities and achieve ICAR's strategic goals to ensure agricultural and rural prosperity. ICAR solves societal challenges through collaboration with our other partners, including academic and science organizations; small business and industry; agencies from all levels of government; and non-governmental, public, and private organizations. ICAR continued strong collaboration with other agencies to help Indian agriculture to become more efficient and competitive, to sustain natural resources and the environment, to enhance the safety of our nation's food supply and improve nutrition.

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 a 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.

ICAR has focused on different aspects of Agricultural Research such as food security and supply; food, nutrition and human health promotion and next-generation food system; climate and energy needs; sustainable use of natural resources; food safety; small business innovation and product development; and agricultural education and workforce development. ICAR has played a major role in promoting excellence in higher education in agriculture and coordinating education in all state agricultural universities and central agricultural universities. ICAR vigorously pursued the deployment of digital platforms in agriculture and the application of ICT for farmers' empowerment.

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.

Soil and water management for sustainable yield: The digital soil mapping framework has been developed using AVIRIS-NG Hyper spectral data, STRM data (30 m), and Sentinel-2 data, and prepared Geo-referenced desertification map of Rajasthan (1 : 500,000 scale) using Indian remote sensing satellite images (IRS-AWiFs), mapping of groundwater potential zones and identification of recharge structures in hard rock areas. Granular minerals fertilizer was developed as an alternative to conventional P and K fertilizer, mechanized technique for seed coating of biofertilizer and a soil biological health kit. Besides, a mini pan evaporimeter for on-farm irrigation scheduling, cut-soiler technology for reclamation of saline soils and a bio-consortia for enhancing the productivity of agri-horticultural crops were standardized.

CSR GROW-SURE, a unique bio-stimulant comprising highly efficient salt tolerant bacteria was developed. The formulation was tested for growth and yield parameters in tomato, and banana cultivated in sodic soils of pH 9.14–9.30 and partially reclaimed sodic soils of pH 9.2, respectively and found more effective than CSR-Bio. Plastic mulching in oil palm was effective in enhancing water-use efficiency as it recorded almost comparable yields with micro jet irrigation. Plastic mulching was effective in saving 25% water in drought conditions. Thematic maps were developed for soil suitability for grape growing in Maharashtra, Madhya Pradesh and West Bengal. These maps will be useful for the identification of regions suitable for growing grapes in non-traditional areas and for round the year availability. Tomato cultivars Kashi Aman and Kashi Adarsh tolerated moderate salinity when grafted over brinjal rootstocks.

Climate change and resilient agriculture: Carbon sequestration potential of the floodplain wetlands was assessed in Assam and West Bengal. In Assam wetlands, C deposit up to 30 cm depth of soil was higher (1.7 to 4.2 times) than in the reference upland sites. The estimated C in wetlands of West Bengal revealed higher accumulation (1.67 to 2.3 times) than corresponding upland sites. The carbon footprint was assessed in different rice production systems (zero-till, aerobic and shallow lowland) through total life cycle analysis. The study revealed that aerobic rice emitted lowest total GHG-C-eq/tonne followed by ZTR and SLR, respectively. For production of one tonne of rice, the GHG emissions were 0.73, 0.76 and 0.87 C-eq/tonne in ZTR, AR and SLR, respectively.

A multiple-stress tolerant rice variety Swarna Samriddhi Dhan was notified and released for cultivation in lowland ecosystem of Bihar. Swarna Samriddhi Dhan is a medium duration, high-yielding, multiple-stress (drought,

submergence, disease and insect pests) tolerant, with desirable cooking quality traits and has long slender grains. A drought-tolerant rice variety Swarna Sukha Dhan was released for cultivation in drought-prone upland ecology of Uttar Pradesh. Swarna Sukha Dhan is a short duration, high-yielding and multiple-stress (drought, diseases and insect pests) tolerant with acceptable cooking quality traits. The impact of adoption of Low Tunnel Technologies (LTT) for cultivation of vegetables during off season (winter) in Bikaner, Rajasthan was assessed. LTT for vegetable production has spread over 1,200 ha and farmers earn ₹ 2–3 lakh net profit from one ha per season depending on type of vegetable, seed quality, climatic conditions and marketing demand. The resilience to heat stress in different indigenous goat breeds (Salem Black, Malabari, Osmanabadi, Kanni Aadu and Kodi Aadu) was assessed.

Genetic resources: About 25 explorations were carried out and 1,409 accessions (comprising 772 cultivated and 637 wild) were collected from Assam, Arunachal Pradesh, Bihar, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Chhattisgarh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand and Uttar Pradesh. Germplasm accessions were found in 45% in wild species/CWR. Germplasm included to the National Genebank for long-term storage comprised 8,622 accessions of orthodox seed species and till date the base collection of National Genebank has a total of 4,56,568 accessions. In the cryogenebank, 237 accessions of seeds and pollen genomic resources of different crop species were successfully cryopreserved, making overall collection of 12,076 accessions. A total of 41,490 samples of trait specific accessions were imported from 36 countries. Screening against biotic and abiotic stresses in different crops was carried out in 8,500 and 9,215 accessions, respectively. Biochemical evaluation of 6,580 accessions was undertaken in different crops for oil content, protein, sugar, amino acids, antioxidants and active principles. About 1,22,736 imported samples were processed for quarantine clearance. The total collection in National Genomic Resource Repository (NGRR) is 9,094 from 46 species. The whole genome sequence of cardamom variety Njallani Green Gold has been assembled at a N50 of ~151 kb with 72% BUSCO completeness.

On fruits, germplasm such as banana (18), citrus (5), guava (3), mango (30), jamun (1), rose apple (5), jackfruit (40), pine apple (7), avocado (53) and one each in acid lime, ber, custard apple, guava, wood apple were collected. In plantation crops, a total of three new germplasm accessions of areca nut were collected. In vegetable, germplasm in various crops such as chilli (24), brinjal (3), watermelon (3), muskmelon (5), okra (27), Dolichos bean (17), onion (3), radish (10), bitter gourd (6), ridge gourd (3), cucumber (60), cluster bean (2), bottle gourd (8), bell pepper (16), drumstick (77), curry leaf (17), summer squash (33), amaranth (9) were collected. In flowers, germplasm in various crops such as tuberose (1), gladiolus (12), gerbera (16), dahlia (30); and in medicinal plants germplasm in crops such as gudmar *Gymnema sylvestre* (31), brahmi *Bacopa monnieri* (71), bhringaraj *Eclipta alba* (53) and mushroom (2) were collected.

In livestock, registered breeds of Dharwadi and Manda buffalo; and Rajapalayam, Chippiparia and Mudhol Hound dog were gazette notified by the Government of India. Monyul cattle of Tawang and West Kameng districts of Arunachal Pradesh was characterized. Monyul cattle are reared for milk, manure and draught. Multivariate analysis was conducted for different biometric traits of 3,282 cattle of 21 native cattle breeds/ populations of the country.

Germplasm repository at National Gene Bank, ICAR-NBAGR, Karnal is being strengthened by preserving diversified form of germplasm (semen, somatic cells and DNA). Total 10,030 semen doses of native breeds (Sahiwal cattle, Nili Ravi buffalo, Marwari, Manipuri, Zanskari horses and Halari donkey) and 970 somatic cell doses of native breeds (Tharparkar cattle, Sirohi and Rohikhandi goat, Mewari, Jalori and Marwari camel and Ghurrah pig) were added during the period for cryopreservation.

The new fish species, viz. snake eel, *Xyrias anjaalai* sp. nov. obtained from deep sea off Kollam, Kerala and *Badis kaladanensis*, a new percoid fish from Mizoram were recorded and described.

Crop improvement: During 2020–21, a total of 254 varieties/ hybrids including 35 special traits varieties of crops were notified and released for commercial cultivation. These varieties comprised: cereals such as rice 39, wheat19, maize 19, pearl millet 3, finger millet 4, barley 1, sorghum 1, little millet 1 and kodo millet 1; Oilseeds such as soybean 25, rapeseed-mustard 7, groundnut 4, linseed 6, sesame 2, safflower 1, castor 1; Pulses—chickpea 13, pigeonpea 8, lentil 4, field pea 3, faba bean 2, mungbean 1, and clusterbean 1; Commercial crops—cotton 62, sugarcane 6, jute 2, mesta 1; Forage and other crops—oat 6, amaranth 4, forage sorghum 2, pearl millet 2, berseem 1, kalingda 1 and dhaincha 1.

Cajanus platycarpus, a non-crossable wild relative of pigeonpea, possesses resistance to polyphagus insect pest *Helicoverpa armigera*. The putative insect resistance genes have been cloned from *C. platycarpus* and are being validated in *Nicotiana tabacum.* The intra-specific genetic linkage maps of chickpea was utilized to 15 quantitative trait loci (QTL) associated with drought traits (membrane stability index, relative water content, seed weight and yield under stress) accounting for phenotypic variations ranging from 11.8 to 27.1%. CRISPR-Cas9 genome editing was used to develop mutants of *drought and salt tolerance* gene encoding a zinc finger transcription factor for improving salt and drought tolerance in rice. Three homozygous transgene free mutants were developed which were more tolerant to salt stress and produced more grains as compared with wild type MTU 1010. Using PacBio and Illumina Mate-pair reads, first ever reported chloroplast and mitochondrial genome of Indian tea were successfully assembled and analyzed. Chloroplast genome comprised 126 genes while mitochondrial genome has 66 genes. Twenty eight diverse tropical maize genotypes were evaluated for their embryogenic callus induction potential using mature seed derived two different explants under two different callusing media, out of 28 genotypes, better callus induction was achieved in four genotypes from nodal explants.

During the year, total production of quality seed including all classes was 3,03,130.2 q against the target of 3,32,055.3 q. Production comprised 79,373.3 q of foundation seed, 1,18,487 q of certified seeds, 77,376.4 q of truthfully labeled seed and 27,893.5 q of planting material of field crops. A

total of 98 varieties of horticultural crops were identified and Notified by the Central Sub-Committee on Crop Standards, Notification and Release of varieties for Horticultural Crops in its 28th Meeting. These include 15 in fruit crops (sweet orange-1, acid lime-2, grapes-2, mango-5, banana-5), 29 in vegetable crops (brinjal-5, chilli and capsicum-5, one each in radish, cauliflower, bottle gourd, cucumber, ridge gourd, spine gourd, French bean, long melon; pea and beans-5; tomato-6); three in bulbous crops (garlic-2, onion-1), 23 in potato and tropical tuber crops (potato-8, cassava-5, yams-7, Colocassia/arvi including Sakhen Bunda-3), eight in plantation crops (coconut-6, arecanut-1 and oil palm-1), nine in spices (three each in turmeric and coriander and one each in celery, fenugreek and ajwain) and eleven in flowers (aster-1 and five each in marigold and chrysanthemum).

In apple, a total of five hybrids were developed namely Anmol for early maturity, Ambrit with typical ambri flavour, Priame, Pride and Pritor with scab resistance. In coconut, Kalpa Ratna suitable for tender nut, copra and inflorescence sap production, and Kalpa Raja a promising tall variety for the root (wilt) disease prevalent tract have been developed. The productivity is 133 nuts/palm/year, in Kalpa Ratna, whereas 158 nuts/palm in Kalpa Raja. The dwarf varieties of cashew, such as Nethra Vaaman (<2m height, yield 1–2 kg/plant) and KAU Nihara (yield 2 kg/plant) were identified. Arka Shyama watermelon variety, with dark red, crispy, sweet pulp, 3–4 kg weight, early harvest (65–70 days) and yield potential 62.8 tonnes/ha was developed. Arka Neelachal Pushti Indian bean (Sem), a high-yielding, pole type, round padded variety which is rich in protein and micronutrients and is ideal for cultivation in eastern India. The average yield was 24 tonnes/ha in 120 days. Resistant varieties of vegetables developed were: Kalinga Brinjal 131 (BB 67) and Arka Avinash brinjal (resistant to bacterial wilt); MS/11-664 potato (resistant to late blight); T Ca 14-5 and 8S 501-2 cassava (resistant to cassava mosaic disease); TGy 14-6 greater yam (resistant to anthracnose); Gujarat Navsari Mango Ginger 2 ginger (resistant to rhizome rot and leaf blight); CG Raigarh Haldi 3 turmeric (moderately resistant to *Colletotrichum* leaf spot and *Taphrina* leaf blotch); Karan Sounf 1 fennel (resistant to *Rumularia* blight); CG Raigarh Dhaniya 3 and Ajmer Green Coriander 1 coriander (resistant to powdery mildew and aphids); Hisar Methi 273 (resistant to downy mildew and tolerant to powdery mildew) and Gujarat Methi 3 (less prone to powdery mildew) fenugreek; Ajmer Ajwain 73 ajwain (tolerant to root rot); and Ajmer Nigella 1 nigella (tolerant to root rot). In button mushroom varieties NBS 5-1084 and NBS 5-773, paddy straw mushroom DMRO 1072 and DMRO 995, oyster mushroom strain H3 and shiitake mushroom strain DMRO 327 were recommended for release for commercial cultivation.

Livestock improvement: A total of 25,323 Artificial inseminations in Frieswal were carried out from which 4,140 female progenies were born and 1,209 daughters reached the age of first calving. In Avishaan flock of sheep, ewe productivity efficiency (EPE) was 4.22 and 22.90 kg at birth and 3 month of age, respectively. A total of 535 male and 192 female sheep of different breeds were supplied for genetic improvement of farmer's flock. Improved Jamunapari, Barbari and Jakhrana goats were supplied for genetic improvement programme in farmer's flock. The overall mean milk yield in 90 days and 140 days was 75.38±1.84 and 111.46±2.99 litre, respectively; and lactation length was 161.04±3.24 days. In Barbari goat, overall mean for 90 days and 140 days milk yield was 60.75±0.85 and 82.55±1.29 litre, respectively; and lactation length was 134.87±1.82 days.

At Anand centre of AICRP on Poultry Breeding, the 40 weeks egg production of Ankleshwar (S-2) was 76.38 eggs, while 72 weeks egg production in IWH and IWP strains (S-1) was 307.2 and 317.5 eggs, respectively. Egg production of IWD and IWK strains (S-8) up to 64 weeks was 226.5 and 218.1 eggs, respectively. A total of 4,19,477 improved chicken germplasm was distributed by different centres in their respective regions/states. CARI-Gracy and CARl-Nirsafed were developed to address issues of climate change for backyard poultry. The dual type hardy birds are efficient egg producers even in intense summer, and also good meat producers. This will help increasing farmers' income by maximizing production throughout the year.

In fisheries, picnic seabream or black seabream (*Acanthopugrus berda*) has high economic and recreational values, excellent meat quality and ability to tolerate wide variations in environmental conditions. Its breeding and seed production were achieved by induced breeding using salmon-GnRH-analogue hormone. Grey mullet (*Mugil cephalus*) a high-valued commercial brackishwater fish, was successfully bred under controlled captive conditions for the first time in the country. Technology on carp sperm cryopreservation was field-tested and successfully upscaled for use in improving hatchery seed quality and genetic exchange through field demonstrations. During the year 800 ml of milt from riverine stocks of Indian major carp was cryopreserved and stored in cryobank. In view of the emerging importance of seaweed mariculture, an all-India preliminary site selection survey suitable for seaweed farming was conducted. A total of 1,677 differentially expressed genes were identified in *Catla catla* through transcriptome analysis. Fourteen differentially expressed regulatory hub genes for growth were also identified. The fish-derived bioactive peptides can prove to be a natural and less toxic therapeutic source.

Crop management: Pusa decomposer is a microbial consortium of fungi developed for accelerated degradation of paddy straw into manure in 20–25 days. This technology is an effective eco-friendly solution for agri-residue management, alternative to burning thereby decreasing air pollution and improving soil health. An endospores-based liquid formulation CRIJAF SONA was developed for jute retting which can be completed within 12 days and the resulting jute fibre has a better strength. Rainfed monocropping systems have low yield and lead to low income. Therefore, an Integrated Farming System (IFS) model was developed for rainfed cotton-based system for central India. Overall, one-ha IFS model produced 70.2 q/ha cotton-equivalent yield with a benefit: cost ratio of 1.95. The biopolymers can be used as a seed coating material and carrier matrix for entrapment of agri inputs. These polymers were utilized for entrapment of beneficial microbes like *Trichoderma* which enhances productivity between 20–30%.

Two promising *Trichoderma* isolates were identified with the potential to enhance sugarcane yield by 17–24.5% under low inorganic fertilizer usage. For the first time leaf spot

(Curcularia geniculata) has been observed on maize in India. A study was conducted to isolate and identify efficient bacterial endophytes for wheat to enhance further the genetic potential of low accumulating genotypes for update and translocation of iron and zinc in grains and plant parts. The isolates DS-178 (*Bacillus subtilis*) and DS-179 (*Arthrobacter* sp.) were more for zinc acquisition, whereas DS-68 (*Arthrobacter sulfonivorans*) and DS-163 (*Enterococcus hirae*) were efficient for iron acquisition in grains. Topramezone, promising herbicides is found to be effective to control broadleaved weeds and some of the narrow leaved weeds. Adult weevils of bioagent *Cyrtobagous saliviniae*, were released in aquatic weed (*Salvinia molesta*) in Madhya Pradesh. Complete control of the weed was achieved within six months and there was no regeneration of weed thereafter.

In horticulture, clay-polymer composites using starch, guar-gum, chitosan as polymer and clay, sugarcane bagasse and grape pomace as filler were synthesized. Clay-polymer composites and nano particles as fertilizer carrier will help in increasing micronutrient use efficiency especially in case of Fe and Zn having low availability in calcareous soils. A Litchi maturity kit that provides an easy and handy option to accurately judge acidity of litchi fruit was developed. The attainment of 18–20 BTSS and acidity of less than 0.5% is a reliable indicator of optimum fruit maturity. Two formulations of nutrient mixture, viz. Kalpa Poshak and Kalpa Vardhini were developed for enhancement of growth of juvenile palms and improving the productivity of adult palms, respectively. About 37% increase in nut yield was observed in the palms. The liquid nutrient formulation Akra Sasya Poshak Ras, a unique balanced blend of the macro and micronutrients was developed. This formulation is suitable for commonly grown vegetables.

Integrated management schedule for stem-borer (*Dervishiya cadambas*) in grapes was standardized which comprised removal of loose bark from main trunk and cordons during July–August and washing (2 ml/l water) them with *Metarhizium brunneum* (5×10^8 spores/ml) @ 1.5 to 2 litre formulation/plant. The resistance in different *I pomoea* sp. (*I. palmata, I. triloba, I. mauritiana,* and *I. obscura*) against sweet potato weevil was studied by choice assay test. The Arka Viral Kit is based on Loop-mediated Isothernal Amplification (LAMP) to diagnose Tomato Leaf curl Bangalore virus (ToLCBV). It is user friendly, as the testing can be done in a water bath or dry bath, and cost-effective compared to other PCR based diagnostic kits.

Livestock management: Feeding of maize sprouts with straw bedding to crossbred dairy cows during early to mid-lactation in addition to the existing feeding practice increased milk yield and milk fat and SNF. The body weight gain and feed efficiency improved, and stress indices reduced in broiler chicken with supplementation of methyl donors like betaine, B_{12}, folic acid or biotin having no supplemental methinonine. Different bajra cultivars could totally replace maize in the diet of broiler chicken.

Embryo transfer technology (ETT) was initiated in Kankrej cattle for faster multiplication of superior germplasm. Out of seven embryos retrieved from two cows, five good-quality embryos were transferred into four recipients, Established one OPU-IVF pregnancy of Sahiwal cow. Multiplication of elite buffaloes by cloning and ovum pick up technique was achieved, five pregnancies from embryos in buffalo; six calves born through AI using semen of cloned bulls and seven pregnancies through AI from semen of cloned bulls are ongoing. Buffalo pregnancy diagnosis kit Preg-D was developed. The Preg-D kit is the prototype of a urine based novel technique for pregnancy diagnosis in dairy animals. Buffalo Saliva Scope, an estrus identification kit was developed. An alternative package of practices of mithun rearing under a semi-intensive rearing was developed. Under this system, the mithuns can be monitored by the owner regularly for growth, reproduction, health care, and breeding. Nine units of this system were established benefitting 334 mithun farmers.

The National Animal Disease Referall Expert System v2 (NADRESv2), a dynamic geographic information and remote sensing-enabled expert system, developed and maintained by ICAR-NIVEDI was updated with 3,262 district wise livestock disease outbreaks data from November 2020 to September 2021. The prediction results, risk maps, bulletins, and post-prediction maps were updated on NADRESv2 and automated messages were sent to National Animal Disease Epidemiology Net work centres and further disseminated through forecasting bulletin to all the state Animal Husbandry Departments and Department of Animal Husbandry and Dairying, Government of India, for initiating preventive action for disease. A marker vaccine candidate for *Peste des petits* ruminants (PPR) was developed through reverse genetics. The backbone of the PPR vaccine virus, PPRV/Sungri/96 was used, as this attenuated virus is being successfully used for PPR control in India for over two decades. ICAR-NIHSAD developed the Lateral Flow Rapid Test Kit for Pen-side detection of avian influenza H5 virus antigen in suspected chicken flocks. The test is simple to perform at low cost, and provides rapid diagnosis within 20 min. An SYBR green-based FMDV-3D specific ane-step real-time RT-PCR (rRT-PCR) test was developed for pan-serotype identification of FMD virus. This test is 10 times more sensitive than the traditional agarose gel electrophoresis-based RT-multiplex PCR (RT-mPCR). Complete genome sequence of 4H5H/ highly pathogenic avian influenza (HPAI) viruses and 7H5N8 HPAI viruses isolated from chicken, ducks, crows, crows, wild birds and bar-headed goose was determined.

In fisheries, a starter microbial consortium named CIBAFLOC was developed which facilitates *in-situ* bioremediation, cleaning of nitrogenous wastes in the rearing water and get converted into nutrient-rich microbial biomass. Goldfish hematopoietic necrosis viral disease (GHNVD) has led to worldwide economic losses in goldfish aquaculture. Virus was inactivated with formalin and the vaccine for cyprinid herpes virus (CyHV-2) was developed by using fantail goldfish fin (FtGF) cell line for its propagation. The results have proven that the formalin-inactivated vaccines were efficient and it resulted in triggering the immune gene expression in goldfish. Viral nervous necrosis (VNN) is an acute viral disease affecting more than 120 species of marine, brackishwater and freshwater fish causing up to 100% mortality in larval and juvenile fishes. A recombinant vaccine, CIBA-Nodavac-R against VNM was developed. It can effectively prevent VNN caused by RGNNV (red-spotted grouper nervous necrosis virus) in fingerlings and prevent vertical transmission in brooders. The vaccine is safe and efficacious.

Mechanization and energy management: A tractor-operated variable width raised bed drip lateral-cum-plastic mulch laying machine was developed. This machine is able to form bed of 0.6 to 1.0 m in width and 0.15 m in height. A tractor-operated 19-row garlic weeder was developed. Average weeding efficiency and plant damage by garlic weeder are 69.6% and 0.1%, respectively. A tractor front mounted hydraulically operated two-row pigeon pea harvester was developed. It saved 40% cost and 96% labour when compared with manual method of harvesting.

Hill farming needs versatile agricultural machinery, which should be light in weight for transportation in hilly areas and portable. So a light-weight multi-crop thresher was developed for threshing wheat, paddy, minor millets, and amaranth crops commonly grown in Uttarakhand hills. The multi-crop thresher would benefit hill farmers by saving time and labour and reducing the drudgery involved in the traditional/ manual threshing operations. A tractor-operated drainage trencher for laying sub-surface pipes was developed and evaluated. The developed trencher can make the trench up to the depth of 1.0–1.1 m with width of 150–160 mm. The cost of the trencher was ₹ 3,00,000 and cost of operation is about ₹ 1,300/h. The climate smart machinery such as roto-till-drill, broad-bed and furrow planters, laser land leveller, ridge and furrow planter and mole drainage technology were identified to overcome the adverse effect of climate change and degrading natural resources. The total input energy in wheat production after adopting roto-till drill (21.1 GJ/ha) is about 39% lower as compared to conventional practices (34.9 GJ/ha). The carbon emission in roto-till drill is 1,670 kg of equivalent C/ha which is 9% less as compared to conventional practice (1,834 kg of equivalent C/ha). A tractor-operated multi-row paper-tape vegetable transplanter was developed to save on labour, time and cost of vegetable production. It is a 6-row transplanting machine mounted on 3-point linkage of tractor. The field capacity of the transplanter was 0.25 ha/h and fuel consumption of 2.8 l/h. A battery-operated pruner for horticultural crops was developed. The device was tested on ber, guava, wax apple and mango. The cost of machine is ₹ 2,625 and operation cost is ₹ 39.48/h. A pollinator for greenhouse was designed on the principle of a pulsating air jet for pollination. The highest pollination efficiency (83.66%) was achieved at 1.99 m^3/min airflow rate, 23.50 Hz pulsation frequency and exposure time 19.40 sec. The yield was higher with developed pollinator compared to pollination by a blower (36.6%) and controlled plot (95.7%). The bullock powered, rotary mode driven feed type sunflower thresher has been developed. The average output of the thresher was 65 kg/h with efficiency of threshing as 99% and cleaning 85%. Solar-assisted e-prime mover was developed for weeding and spraying in soybean crop. A three-cylinder tractor diesel engine was modified to run using 100% compressed natural gas (CNG). The engine was successfully operated using 100% CNG under no load condition. Pusa-Farm Sun Fridge for storage of perishables, can be built by farmers from locally available materials and does not need electrical supply or batteries for cooling. The structure of size 3×3×3 m and 2 tonnes capacity uses 12 solar panels @ 415 W each. Pusa-FSF could achieve daytime temperatures as low as approximately 4–6°C when the daily ambient maximum temperature reaches about 45°C.

Post-harvest management and value-addition: IoT-based smart storage structure for pulses was developed for one-tonne storage bin, based on the developed protocol. It includes three sensor modules, and each module has a carbon dioxide sensor, temperature and RH sensor, and a display unit. One module has an oxygen sensor also. Maize cobs are harvested at around 35% moisture content while shelling operation is performed at around 17% moisture content. Therefore a hot air maize cob dryer was developed with 150 kg capacity. The drying is carried out at 60°C, and it takes 24–27 h to reach the final moisture content of 17–18% at the atmospheric temperature (36.86°C) at RH (51.37%). Certain fungi that are found in agricultural crops such as maize, peanuts, cotton seed, chillies etc. produce aflatoxins. These are carcinogenic and impose qualitative and quantitative losses to the agricultural produce. The lateral flow immuno assay (LFIA) device was developed for detection of toxins in the agricultural crops. A natural ventilator based modular onion storage system of one tonne capacity was developed. The storage study of the onions indicated 18% physiological weight loss, 5.5% rotting and 0.2% sprouting losses of stored onions. A power operated baby corm dehusker was developed to reduce the drudgery in dehusking of baby corn. It has capacity of 25 kg/h. Slitting efficiency, dehusking efficiency and desilking efficiency of this machine are 100, 92 and 100%, respectively. Composite yarns prepared by wrapping conductive carbon filaments with cotton fibres through friction spinning were used to develop flexible heat generating pads for multiple applications. These include heating shoe pads, thermal garments, warming seat covers, heating gloves etc. which can be operated by 5V, 2A DC power supply.

Nutri-cereals such as bajra and maize are highly nutritious and are even superior to rice and wheat in various nutritional constituents. In spite of all these benefits, bajra and maize occupy a lower position in human food chain in comparison to staple food grains and are not popular among consumers due to lack of good dough making quality, which limits their application in routine bakery products and in chapatti making. To address this problem, vital wheat gluten (VWG) protein added for reconstitution of bajra and maize flour and products such as Hallur: Soft Bajra Atta and Makai: Soft Makka Atta were developed. These products were as good as wheat for superior dough quality. The VWG was extracted from wheat flour. Superior nutritional composition of Hallur: Soft Bajra Atta and Makkai: Soft Makka Atta will boost their consumption, and also enable farmers to have incentive to grow more nutri cereals.

Agricultural human resource development: ICAR ensures quality assurance of AUs through accreditation and ranking process. Connectivity and availability of e-resources across libraries, connectivity of libraries on a single platform through uniform solutions, along with emphasis on capacity building of the students and faculties through various training programmes under the scheme as well as NAHEP and NAARM has raised the standard of PG research as evident by increased number of publications in high impact journals. AUs were also supported for encouraging holistic development of students, through creation of placement cells, support for sports facilities.

Various programmes/activities also facilitated promotion of higher agricultural education and also helped reduce

academic inbreeding, infuse merit and promote national integration in AUs. These include centralized admissions in UG/PG and Ph.D.; award and distribution of fellowships to attract and retain the talent and promote merit, admission of foreign students for globalization of agricultural education, 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.

The key components of NAHEP, viz. Centres for Advanced Agricultural Sciences and Technology (CAAST), Institutional development Plan (IDP), and Innovation Grants improved performance of AUs through entrepreneurship opportunities, non accredited AUs attaining accreditation and helped accelerate institutional reforms. 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, start ups for agripreneurship.

Social science: Income scenario of agricultural households in India along with variations in various income components were examined across different rounds of the Situation Assessment Survey of Agricultural Households (SAS-AH). Agricultural households usually derived income from farm and non-farm sources. Agricultural sustainability report of 24 Indian states, studied using 51 indicators across four dimensions (soil, water, environmental and socio-economic), revealed that a moderate level of agricultural sustainability in India with the Composite Index of Agricultural Sustainability (CIAS 0.41–0.57). The inter-state variations in CIAS are quite pronounced. An android-based application-eLISS data collection app was developed to capture data from the field for major livestock products. The KISAAN 2:0 (Krishi Integrated Solution for Agri Apps Navigation) App, was envisaged to help e-agriculture and to drive smart phone based agriculture in India. This app integrates more than 300 Agricultural related apps developed by ICAR Institutes. KISAAN 2.0 app provides a single interface in multiple Indian languages for Indian farmers to access agricultural knowledge about crops, horticulture, livestock, fisheries, natural resource management, agricultural engineering, agricultural education and agricultural extension. Black Pepper Drought Transcriptome Database (BPDRTDb) consists of characterizations of black pepper genotype and its web resource will serve as valuable resources for new genes discovery as well as developing SSR maskers in endeavour of higher crop production.

ICAR carried out research activities focusing on farm women nutritional security, livelihood enhancement, technological empowerment, drudgery reduction and entrepreneurship development. Under the ICAR-CIWA-IRRI collaborative project a Women Farmer Producer Company named “Chitri Dora” was formed with the help of guarantee partner PRAGATI at Koraput involving 1,031 tribal women farmers, covering 30 producer groups, for collective marketing of aromatic rice. For farm women a manual disc ridger was also developed and tested for operational parameters to form ridges and channel with proper work rest cycle. The output capacity is 427 m^2/h, which is more than 5 times the traditional method of using spade.

Information, communication and publicity services: The ICAR-DKMA publishes periodicals, books, handbooks, Annual Reports, newsletters, bulletins, monographs, e-books, media columns, social media contents and advisories. The knowledge banks are available in open access as well as in closed access models to the stakeholders in agriculture. ICAR-DKMA has already taken steps to disseminate knowledge by using up-to-date most popular ICT tools for benefitting the national as well as international agricultural world. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, the monthly research journals of international repute are in the open access mode (http://epubs.icar.org.in/ejournal). The journals have a wide clientele and received a total of 1865 (Animal Sciences) and 2794 (Agricultural Sciences) submissions, respectively during the reporting period. The user base of the journals is expanding and 2125 and 3273 new users have associated making the total tally to 21,154 (Animal Sciences) and 40,926 (Agricultural Sciences) users. The journal website was visited nearly 45000 times with audience belonging to 143 countries. The journals have considerable metrics, viz. impact factor and H index are 0.22 and 26 for Agriculture and 0.21 and 22 for Animal sciences given the fact that these are multi-disciplinary in nature. Popular periodicals like *Indian Farming* and *Indian Horticulture*, and *Kheti* and *Phal Phool* were brought out on topical issues for outreach to the masses.

To disseminate information in real-time, the ICAR website is updated on a regular basis and in total 4,589 pages were updated and a total of 45,77,864 page views from more than 200 countries were recorded. 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 430 posts were published during the year 2021 and it has 2,20,379 Followers. ICAR Twitter handle has more than 1,60,132 Followers. On an average, 3 Tweets are Posted every day and a total of 1,013 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.

ICAR DARPAN Dashboard (https://icar.dashboard.nic.in/login.aspx) provides centralized, easy-to-access platform for display and access of data from multiple sources. To increase the penetration of agricultural technologies and two way effective communication with farmers, multi-media based multilingual ICT based communication system “Kisan Sarathi: An interface solution with farmers” was launched on 93rd foundation day of Indian Council Agricultural Research. The Agricultural Research Management System (ICAR-ARMS**)** has been developed for evaluation, monitoring and management of scientific output for policy planning of the Council. E-HRMS (Human Resource Management System) is a work flow based online solution which consists of creation of e-service book and all processes/information impacting service book from joining to retirement of an employee. Land Record Management Information System (https://lrms.icar.gov.in) is an online solution for Land Record Management of ICAR institutes was developed by IT Unit of IASRI in collaboration with ICT Unit of ICAR Headquarters and Director (Works).

Technology assessment, demonstration and capacity development: Technology assessment is carried out by KVKs, in different locations under various agro-ecological situations. About 5,222 technologies of various crops were assessed at 12,015 locations by conducting 25,843 trials at farmers' field. The different thematic areas were: cropping systems, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated nutrient management, integrated pest management, integrated weed management, processing and value-addition, resource conservation, storage techniques, and varietal assessment of cereals, pulses, oilseeds, fruits, vegetable and commercial crops. A total of 873 technological interventions relating to different livestock were assessed by KVKs at 3,204 locations through 6,646 trials covering thematic areas such as animal disease management, evaluation of breeds, feed and fodder management, nutrition management, livestock production management, and processing and value-addition. About 364 technologies at 1,222 locations through 2,247 trials under other enterprises including mechanization; processing and value-addition; drudgery reduction; small-scale income generation; nursery raising, fish production and management; and household food security.

A detailed programme was planned, prepared and executed on Cluster Frontline Demonstrations (CFLDs) with an aim to demonstrate the production potential of major pulse and oilseed crops in the country. A total of 1,67,026 Frontline Demonstrations (FLDs) on crops, farm machineries, livestock and fisheries, other enterprises and gender-specific technologies for women empowerment were organised. About 45,469 training courses for farmers and farm women targeting productivity enhancement and cost reduction of field crops, horticultural crops, plant protection, empowerment of rural women, livestock production and management, soil health and fertility management, capacity building for group actions, agricultural engineering, production of inputs, fisheries, and agro-forestry.

Capacity development of 1.41 lakh extension personnel was conducted through 4,620 courses in the country. The extension, functionaries engaged both in government and non-government organizations for the development of agricultural sector in the country were included in these trainings. Soil, water, plant and manure samples of farmers' fields were analysed at KVKs, and suitable advisories based on analysis were provided to them. A total of 52 Directorates of Extension Education (DEEs) of the SAUs/CAUs have played a crucial role in technological backstopping to KVKs in India. The DEEs facilitated technological backstopping for KVKs by conducting training programmes, field days, farmer-scientist interactions, soil health camps, kisan melas, kisan goshthies and technology week celebrations.

Research for tribal and hill regions: The varieties released for cultivation were: biofertified maize VLQPM Hybrid 59; grain amaranth VL Chua 110; finger millet VL Mandua 378 and VL Safed Mandua 382; wheat VL Gehun 2015; rice UL Dhan 88, VL Dhan 159 and VL Sikkim Dhan; and Vegetable VL Sabji Matar 14 and VL Cherry Tomato 1. About 187.0 q breeder seed of 47 released varieties of 17 crops were produced. The 9.93 q truthfully labelled seed of 20 varieties of 13 crops was produced. A total of 15.4725 q TL seed was supplied to different stakeholders. An integrated organic farming system (IOFS) model (0.43 ha area) was developed at Umiam, Meghalaya to meet the diverse requirement of the farm household while preserving the resource base and maintaining the ecology. The model has diversified farming components like field crops (cereals, pulses, oilseeds), horticultural crops (vegetables, fruits), livestock (one cow + calf), duckery (20 ducks) along with perennial fodder crops, composting units and central water harvesting pond for composite fish culture and as a source for irrigation during lean season. The IOFS model generated an average net return of ₹ 82,450/year with B : C ratio of 2.43 which are much higher than the common farming practices.

Patent and copyright: During the period under report 70 new patent applications were filed in different sectors of agriculture at Indian Patent Office (IPO). Further, ICAR's cumulative number of granted patents has risen to 408 with grant of 52 patents by IPO from 26 ICAR institute Plant Varieties and Farmers' Rights Authority (PPV&FRA) granted registration certificates for 58 varieties (55 extant and 3 new) during this period. The cumulative figure of registered varieties is 1360s. Research outcomes including software, books, research reports and other creative activities were protected under copyright act by filing 59 applications. A total of 301 copyrights have been registered from different ICAR institutes. Sixteen applications for designs were filed by ICAR-CIFT, Cochin, ICAR-CMFRI, Cochin, NINFET, Kolkata, and ICAR-NRC on Mithun, Nagaland. These included: (i) Fish freshness sensor; (ii) Fish smoking kiln; (iii) Hot air assisted continuous infrared dryer; (iv) Meat and shell separating machine for clams; and (v) Banana pseudo-stem fiber extractor. A total of 73 filed design applications have been registered. Twenty two Trademark applications were filed in different products and brand names, viz. *CAFRI Krishivaniki, CAMMiN, CIFRI ARGCURE, DCFR Aqua FSD fish anaesthetic, Fish Tanavhari, Brahmavarta, KaMilk, NINFET Power, Preg-D, Spiisry, Shining Barb, Srinidhi, Vanashree* etc. Total of 189 trademark applications have been filed by 27 ICAR institutes. Thirty-five ICAR institutions in different Subject Matter Divisions have entered into 417 agreements for consultancy/contract research and services with 240 public and/or private organizations.

Organization and management: Various useful programs for the farmers were organized by the institutes of the Council in Hindi and Regional Languages. All activities related to KVK's located in Hindi Speaking area and agriculture extension activities are also being performed in Hindi and Regional Languages. Various publications on various subjects like agriculture science, animal and fishery science and horticulture science are being brought out in Hindi and Regional Languages by the Council and its Institutes. In-house journal of ICAR Headquarters *Rajbhasha Aalok* is being published regularly. This magazine includes articles on scientific subjects and governments schemes in simple Hindi besides reports of various programmes being organized by the Council and its institutes from time to time.

Meetings of the ICAR Regional Committees No. VI, VII and VIII were held through Video Conferencing. The Regional Committee Meetings held once every two years, provide an ideal platform for reviewing the status of

agricultural research, education and extension in the mandated states and union territories. The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientists, teachers, farmers and agricultural journalists every year. To commemorate 93rd Foundation Day of ICAR, the Award ceremony was organized at Krishi Bhawan, New Delhi, through video conferencing on 16 July 2021. The awards were given in 17 different categories to 63 awardees; these comprised 39 scientists (including 08 women) and 9 farmers (including 2 women farmers). It is heartening to note that of the 39 scientists 8 are women.

Administration: During the year, the following posts were filled up under the promotion quota: fourteen Director/ Joint Director cum Registrar, two Director (F)/Comptroller, five Deputy Director (F)/Chief Finance & Accounts Officer, eleven Deputy-Secretary & nine Chief Administrative Officer, twenty-one Senior Finance & Accounts Officer, twenty-one Under-Secretaries, thirty Senior Administrative Officer, twelve Principle Private Secretary, thirty-four Administrative Officer, twenty-four Finance & Accounts Officer, twenty-three Section Officers, twelve Private Secretary, two Assistant, and three LDC at ICAR Hqrs.

During the year, 61 eligible officers and staff of ICAR (Hqrs.) were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme in accordance with the Government of India (Department of Personnel and Trainings) instructions in this regard.

Finance: The Revised Estimates in respect of DARE/ ICAR for 2020–21 was ₹ 7,762.38 crore. An internal resources of ₹ 273.40 crore (including interest on Loans & Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2020–21. The total allocation Budget Estimates for 2021–22 was ₹ 8,513.62 crore.

Supporting basic and strategic research: The National Agricultural Science Fund supports basic and strategic research in agriculture aimed at fostering research and a research culture and science popularization. At present 78 projects are in operation and out of which 73 are multi institutional in nature. A total of 10 new projects approved, 55 research articles published in reputed journals; two patents granted and nine technologies were developed. Population diversity of banana streak viruses (BSV) and the mechanisms of resistance to BSV in diploid seedy banana of North-east India were deciphered. Whole genome sequencing of *Bacillus thuringiensis* isolate, Bt 62 genome, revealed the presence of *cry8Sal* and *cry8Ib* genes. Bt 62 isolate was found toxic to white grub (*Holotrichia serrata*). The bioassay results indicated that cry8Sal toxin exhibited higher insect mortality of up to 90% as compared to 60% mortality with cry8Ib toxin. Using potential microbial consortia 'Excel Decomposer' was developed for decomposition of different bio-waste. In addition, a drum type composting unit and shredder machine namely 'Excel Composter' and 'Excel Shredr' were also customized and fabricated for enhanced decomposition of organic residues. The 'Excel Decomposer' is also being used for *in-situ* decomposition of rice and wheat residue in farmers' field of Bhopal. Process for biodiesel production from microalgal slurry was standardized. Biodiesel up to 45% of dry weight was obtained from *Chlorella minutissima* biomass.

Training and capacity building: Council organized an online workshop on Training Management Information System (TMIS) to acquaint the participants about the proper functioning of TMIS and its implementation in the institutes/HQs, to submit online Annual Training Plans (ATPs), Training Applications, Training Feedback and Impact Assessment of the Training Programme attended. ICAR-Institutes organized Training Programmes for Finance staff dealing with Accrual Accounting, e-Office Implementation, PME Cell Incharges and Vigilance Officers. Fifteen ICAR-Institutes organized online Training Programme on "Effective Health Management for Enhancing Work Efficiency of ICAR Employees" covering physical, mental, spiritual health along with stress management and positive thinking in which about 1,200 employees attended the programme. During the reporting period, 1519, 955, 615 and 678 scientists, technical, administrative including finance, and SSS were trained, respectively with overall, 3,767 employees were trained even during the Covid-19 Pandemic situation, mostly through virtual mode. Compared to 2013–14, there was considerable improvement in number of employees undergone trainings particularly in case of Scientists, Technical, Administrative and Skilled Support Staff, where improvement was 9.0, 158.1, 1.5 and 1595%, respectively along with overall improvement of 56.4% in all the categories of employees during 2020–21. Compared to 2013–14, ICAR-Institutes/HQs organized 13.4 and 1140% more training programmes for technical and skilled support staff, respectively during 2020–21. Though there was decline in number of trainings due to Covid-19 pandemic but the participation per training increased considerably.

The ICAR and the SAUs system are making a concerted effort to better target research and to improve coordination of programmes across the various institutes. The concerted endeavours are also being made to foster partnership with the farmers and other stakeholders, so as to accelerate the transfer of technology. For a better understanding of the needs of agriculture, the ICAR Annual Report 2021-22 presents the achievements of the Council to the policy planners, researchers and all stakeholders, and hope that these will help them in future research and innovations for the improvement of Indian agriculture.

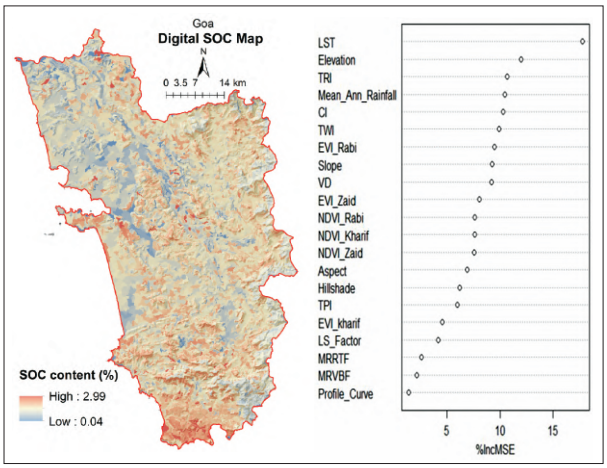
(T Mohapatra)
Secretary
Department of Agricultural Research and Education
and
Director General
Indian Council of Agricultural Research,
New Delhi

2. Soil and Water Productivity

The thrust is on micro-level agricultural land use planning, soil and water conservation, water-harvesting and groundwater recharge, improving water productivity and nutrient use efficiencies, integrated nutrient management, resource conservation technologies, organic farming, integrated farming system, agro-forestry, waste water utilization, hill and coastal agriculture, bio-waste management, weed management, climate-resilient agriculture and abiotic stress management cutting across the states/UTs.

Digital mapping: A framework for digital soil mapping using AVIRIS-NG hyper spectral data, SRTM data (30 m), and Sentinel-2 data were developed to predict soil attributes at taluka level.

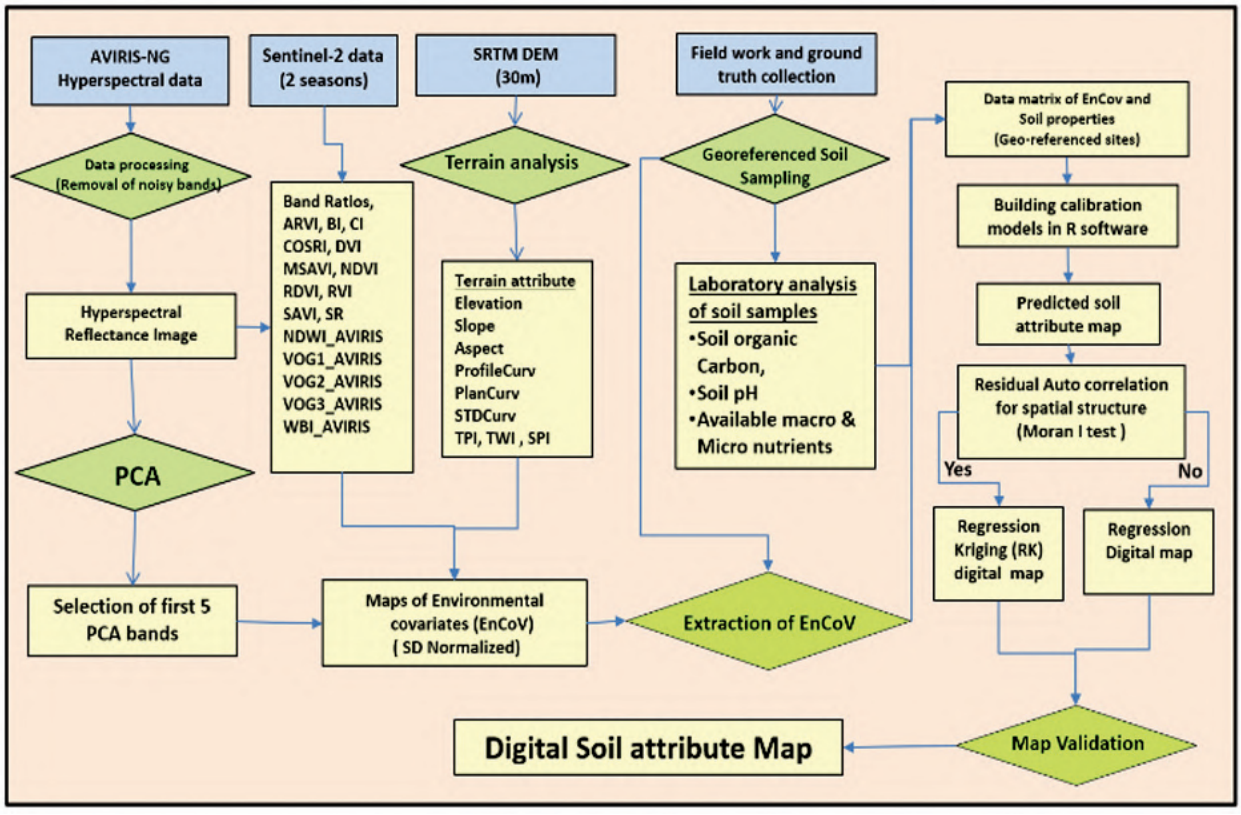
Digital mapping of soil organic carbon (SOC) and soil *p*H in Goa was done using the Quantile Random Forest model. Total six different multivariate models (Elastic neural network (elnet), Random forest, Gradient boosting, K-means neural network, Cubist, and Support vector machine) were evaluated to predict soil *p*H and SOC from soil hyper-spectral data for Goa. In independent validation, the visible and near infrared (VNIR) wavelength range-based elnet model performed better for *p*H prediction and the Fourier-transform infrared (FTIR) wavelength range-based gradient boosting model was better suited to predict SOC.



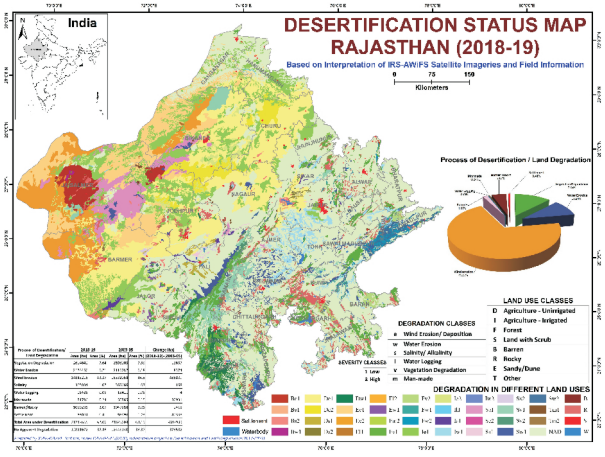
Digital soil organic carbon map and variable chart

Desertification map of Rajasthan: ICAR-CAZRI has prepared geo-referenced desertification map of Rajasthan at 1:500,000 scale based on Indian remote sensing satellite images (IRS-AWiFs) for three seasons (*kharif*, *rabi* and *zaid*) and ground truthing.

The map reveals that 62.06% (21.23 million ha) of the total geographical area in Rajasthan is undergoing



Framework for digital soil mapping using AVIRIS-NG hyper spectral data



Desertification/land degradation map of Rajasthan

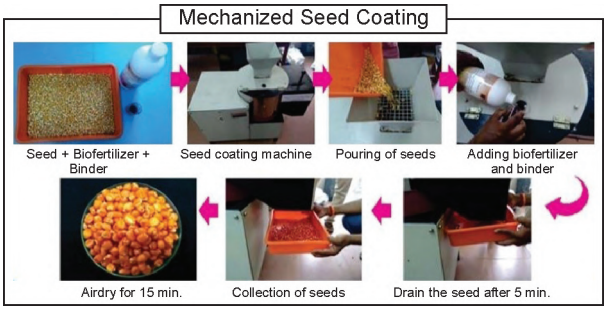
desertification/land degradation (DLD). The most significant process of desertification/land degradation in the state is wind erosion covering 43.37% area followed by degradation due to loss of vegetation (7.64% area), water erosion (6.21% area), salinity (1.07% area) and rest is man-made (0.24% area).

Natural minerals as substitution of P and K fertilizers: The requirement of phosphorus and potash in India is heavily import dependent, putting pressure on government exchequer. While production of phosphatic fertilizers rests on imported raw materials, the potassic fertilizers are totally imported. Indian agriculture depends on imported P (>90%) and K (>95%). ICAR-CAZRI Jodhpur has recently developed a methodology for producing granular mineral fertilizers of P and K for using low grade rock-phosphate (estimated available reserves 312.67 m tonnes in India) and feldspar like orthoclase, microcline (estimated reserves 634 m tonnes in India), respectively. There are a number of steps involved in translating these minerals into fertilizers using a matrix of slowly decomposing C compounds prepared by chemically treating mixture of leonardite (estimated reserves 2.05 billion tonnes) and cellulosic waste. This C containing matrix is used by a range of native heterotrophic P and K solubilizing micro-organisms for their growth, and subsequently releases P and K by solubilizing low-grade rock-phosphate and feldspar, respectively.

The efficacy of these mineral fertilizers was tested on various crops, and gave comparable yield obtained with conventional P (Diammonium phosphate) and K (Muriate of Potash) fertilizers with about 50% lower cost and hence could be an effective substitute of DAP and MoP.

Efficient Zn solubilising biofertilizer: A new zinc solubilising biofertilizer *Pseudomonas striata* capable of solubilising complexed zinc in soil has been developed for Zn deficient soils of Maharashtra under All India Network Project on Soil Biodiversity—Biofertilizers. This strain was found to be more efficient over commonly used organisms like *Bacillus megaterium*. About 26% higher seed yield of pigeon pea was obtained in seed treated with *Pseudomonas striata* than uninoculated control. An INM package consisting of seed treatment with liquid *Pseudomonas striata* as zinc solubilizer @ 100 ml/10 kg seed + 30 kg $ZnSO_4$/ha along with recommended dose of fertilizers was recommended for pigeon pea.

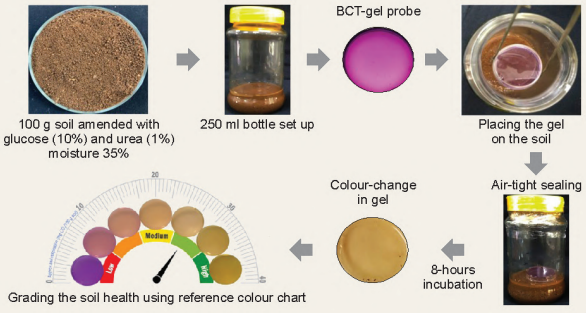
Mechanized seed coating of biofertilizers: A machine was developed for coating of seeds with different microbial formulations under All India Network Project on Soil Biodiversity —Biofertilizers. Organisms like Rhizobium, Azotobacter, Azospirillum, Phosphorus solubilizing bacteria can be coated on seeds one after other with a sticking agent, hydroxyl propyl methylcellulose through film-coating method. The formulation prolonged the survival of the inoculants on the seed (about 10^3 cfu/seed) up to 90 days of storage and enhanced the yield of maize, ragi, red gram and groundnut by 17–34%, with a cost-benefit ratio of 1.31 : 2.97.



Standardized seed coating machine for biofertilizer application. Farmers can coat their seeds with required biofertilizers uniformly.

Soil biological health kit

Soil health largely rely on soil biodiversity and soil biological processes. A kit was developed under All India Network Project on Soil Biodiversity— Biofertilizers to evaluate soil biological health based on substrate induced respiration. The kit contains assemblies to incubate soil with a defined substrate along with an indicator "Gel probe" which changes its colour based on the amount of CO_2 evolved from soil. The colour-change of the gel exhibits positive correlation with actual measure of CO_2 and soil biological quality index. The gel probe's colour change discriminates the soils based on their health status. The kit is a simple, quick and cost-effective method without any instrumentation. The kit will allow the farmer to monitor soil health without much scientific skill and equipment.



Minor millet based agroforestry systems in foothills of NW Himalayas

Small millets play a pivotal role towards nutritional security. The *Morus alba* + finger millet-wheat based agro-forestry system (AFS) in foothills of north-western Himalayas (Dehradun) on 4% slope was found to be most potential for soil-water conservation, productive and environmentally sustainable agro-forestry system among different land uses as it produced 1.4 and 3.1 tonnes/ha of finger millet and wheat grain, respectively.

The recorded runoff was minimum at 21.6% with the soil loss of 12.6 tonnes/ha in comparison to cultivated fallow of 32.9% and 30.2 tonnes/ha, respectively, indicating the higher relative potential for soil-water conservation. It recorded the highest organic carbon of 0.68 which was 2.24 times higher than initial value as that of other soil fertility parameters. While the soil conservation efficiency of multi-purpose trees (MPTs), millet crops and tree-crop combinations was 21, 30 and 36%, respectively, in ascending order and the runoff conservation efficiency was 13.1, 22.4 and 32.6, respectively.

The soil fertility and structure parameters showed marked improvements in tree-crop combinations of the agro-forestry systems land uses. Organic carbon increased from 0.27 to 0.62% in tree-crop combinations, 0.26 to 0.47% in sole trees and 0.27 to 0.41% in sole field crops. The AFS also produced the highest 3.7 and 3.3 tonnes/ha of fresh fodder and dry fuel wood, respectively. Overall, it recorded the highest system productivity with B : C ratio of 1.88 and net returns of 1.19 lakh/ha/yr besides the soil-water conservation potential.

Mini pan evaporimeter for on-farm irrigation scheduling: For scientific irrigation scheduling an inexpensive and easy to use small size pan evaporimeter was developed for on-farm irrigation scheduling by the farmers. The evaporation data recorded using mini pan evaporimeters and USWB Class A pan at ICAR–Indian Institute of Water Management research farm, Bhubaneswar, Odisha were compared for summer, *kharif* and *rabi* seasons. The regression analysis showed that 30 cm GI mini pan had highest regression coefficient (0.86–0.89) with USWB Class A pan followed by 20 cm GI mini pan evaporimeter (0.80–0.87). Field evaluation of mini pan evaporimeters (GI mini pan with 30 and 20 cm diameter) for on-farm irrigation scheduling against USWB Class A open pan evaporimeter during *kharif*, *rabi* and summer seasons showed that the crop (paddy in *kharif*, tomato in *rabi* and maize in summer) yield and yield parameter, and water requirement did not vary significantly with irrigation scheduling using mini pan evaporimeter and USWB Class A pan treatments. Hence, 30 cm diameter GI (20 gauge) mini pan evaporimeter with a height of 25 cm is recommended for use in irrigation scheduling purposes in Eastern India (Odisha).

Mini pan evaporimeters (GI and PVC) of different sizes installed at IIWM

Strategies for improved water productivity in the canal commands: To increase the performance in terms of crop yield and water productivity, supply of canal water through farm-pond fed pipe conveyance based pressurized irrigation system was evaluated in the Nagpur minor of Puri main canal system, Odisha. Accordingly, pipe conveyance system alone; pipe conveyance system along with sprinkler irrigation provision; and pipe conveyance system along with drip irrigation provision were laid out in upper, middle and lower reach of the minor irrigation system, respectively. During four years study period of 2017–2021, overall pipe conveyance based pressurized irrigation system in all the three reaches of the canal system out-performed in terms of crop yield and water productivity in comparison to farmers' practice of channel based conveyance irrigation system. However, among the three different irrigation practices, in the lower reach, pipe conveyance based drip irrigation system out-performed the other two irrigation systems while resulting in enhancement of crop yield of groundnut, pointed gourd and bitter gourd in the range of 34.5–47.2% and water

Pipe conveyance based sprinkler irrigation

Pipe conveyance based drip irrigation

productivity of 137.1–151.8% with less irrigation water use of 40–45.4%, respectively, when compared with channel conveyance system. Channel conveyance system resulted in the crop yield with the range of 1.4–11.8 tonnes/ha, water productivity of 0.5–3.9 kg/m^3 and total water use of 270–300 mm (total 3 irrigations ranging 90–100 mm each time). However, among the three irrigation systems, pipe conveyance based sprinkler irrigation system was preferred by the farming community as it required less effort for operation and maintenance.

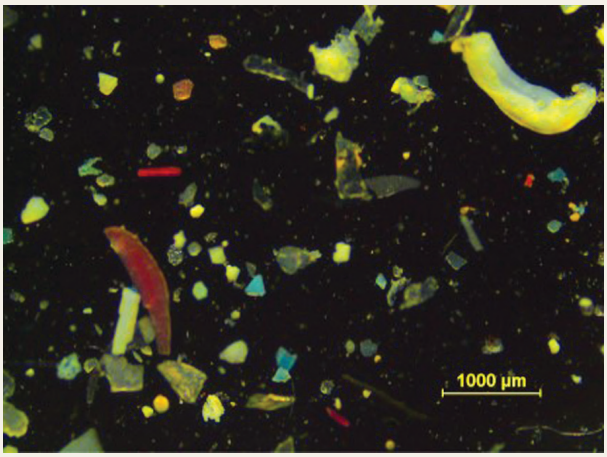
Land shaping in coastal waterlogged areas of Odisha: In coastal waterlogged areas of Odisha, crop diversification and intensification, land shaping options were attempted in lowland field to improve the income of farmers. Two land modification models, viz. raised bed and pond system with undisturbed land in between and alternate raised and furrow bed and aquaculture in

an agroforestry system were evaluated. Alternate raised and furrow bed and aquaculture in an agroforestry system was more beneficial with higher net return of ₹1.68 lakh/ha as compared to the raised bed and pond system with undisturbed land in between (₹ 0.5 lakh/ha). Soil salinity was reduced in raised bed areas during rainy season (up to 0.3 dS/m in September as compared to 3 dS/m in April–May) and helped in crop diversification. Suitable crops

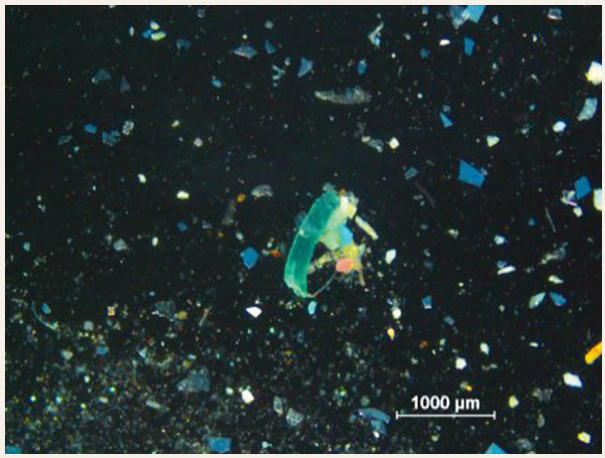
Microplastics contamination in aquatic ecosystems

There is global concern on ill effects of microplastics on humans and other organisms including aquatic biota. Wastewater canals associated with East Kolkata Wetlands are heavily loaded with microplastics (30.46 to 137.72 microplastics/L in surface water and 1,108.78 to 34,612.87 microplastics/kg in sediments) and eventually they contaminate aquatic ecosystems. A number of microplastics of various colour and morphologies were found in the fish guts.It was also found that floating microplastics in the surface water are a major reason for microplastics content in fish guts.

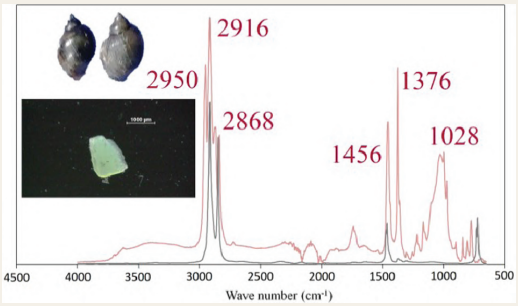
Further, an investigation was made to evaluate the occurrence of microplastics in a typical water treatment plant with a pulse clarification system. In the test water treatment plant, raw water was sourced from river Ganga and found to contain microplastics at a concentration of 17.88 items/L. It was found that different water treatment stages like coagulation-flocculation, pulse clarification and sand filtration reduced the microplastics content in the final treated water. The cumulative microplastic removal at key treatment stages, viz. pulse clarification and sand filtration were found to be 63 and 85%, respectively. The most frequently occurring microplastics were fibres and films/fragments.



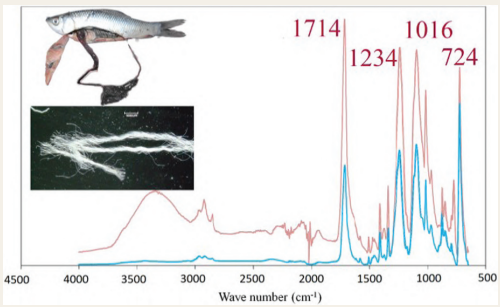
Microplastics found in sediments of wastewater canals



Microplastics found in sediments of East Kolkata Wetlands



Microplastics found in sediments of *Indoplanorbis exustus*

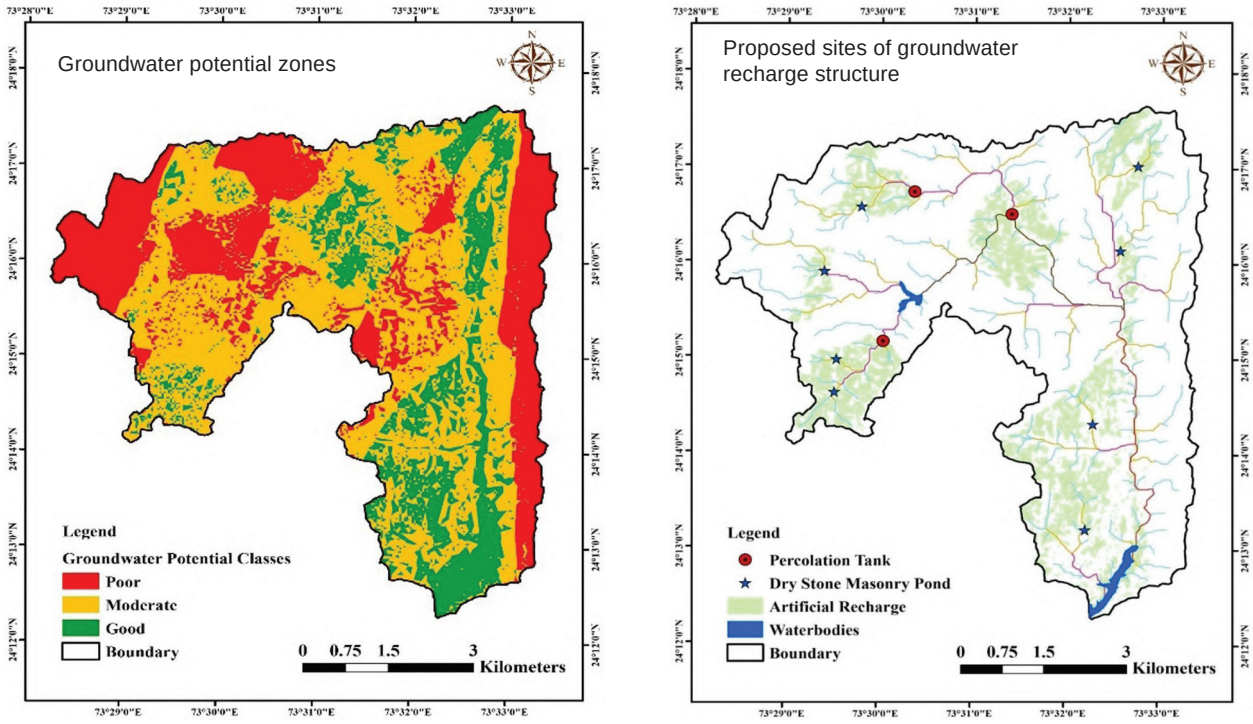


Microplastics found in the gut of *Labeo rohita*

identified for growing on raised beds include green *Amaranth*, brinjal, tomato, ridge gourd, bitter gourd, vegetable nursery and okra.

Mapping of groundwater potential zones and identification of recharge structures: Geo-morphological characterization along with use of thematic maps for delineation and preparation of groundwater potential zone for Kakan watershed in the hard rock areas of Jhadol block, Udaipur district, Rajasthan revealed three distinct zones of good, moderate and poor groundwater potential covering 29.8, 24.5 and 18.5% of total catchment area (47.44 km^2) of the watershed. Groundwater recharge computed for 19 representative sites in the watershed showed average recharge of 6.95 cm/year. Favourable artificial groundwater recharge zones were delineated for the catchment area using remote sensing and GIS, which amounted to 18.06% of the catchment area. Recharge structures such as embankment type percolation tanks and dry stone masonry ponds were recommended for construction in Kakan watershed.

Cut-soiler technology for reclamation of saline soils: Cut-soiler, which cuts and opens V-shape furrow and fills it back with scattered straw and crop residues and kept below 60 cm soil depth have potential to manage both surface water-logging and soil salinity, and could serve as remunerative alternative of subsurface drainage technology for management of salt affected soils in India. Lysimetric study with different artificial conditions to study effects of the technology in different conditions with variable inputs, showed desalinization effect of cut-soiler in saline (6.73 to 5.5 dS/m) and heavy textured soils (0.86 to 0.34 dS/m). Cut-soiler lateral spacing of 2.5, 5.0, 7.5 and 10.0 m reduced 40.2, 27.7, 23.8 and 14.3% salinity

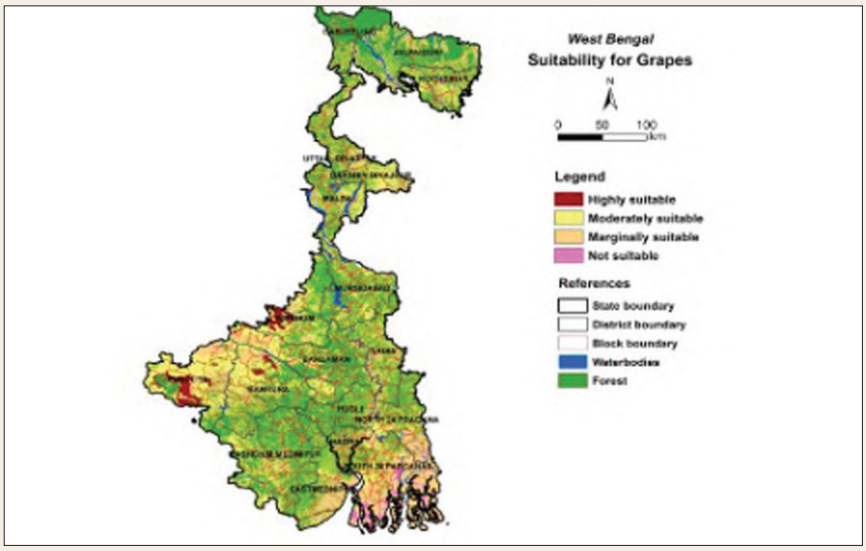


Groundwater potential zones of Kakan watershed (*left*), Proposed sites of groundwater recharge structures (*right*)

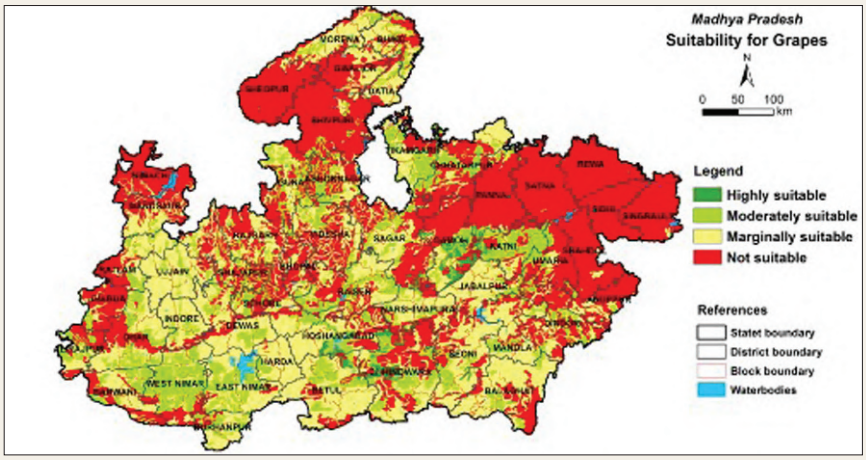
Cut-soiler working under field condition and pearl millet crop

Soil suitability map for grapes

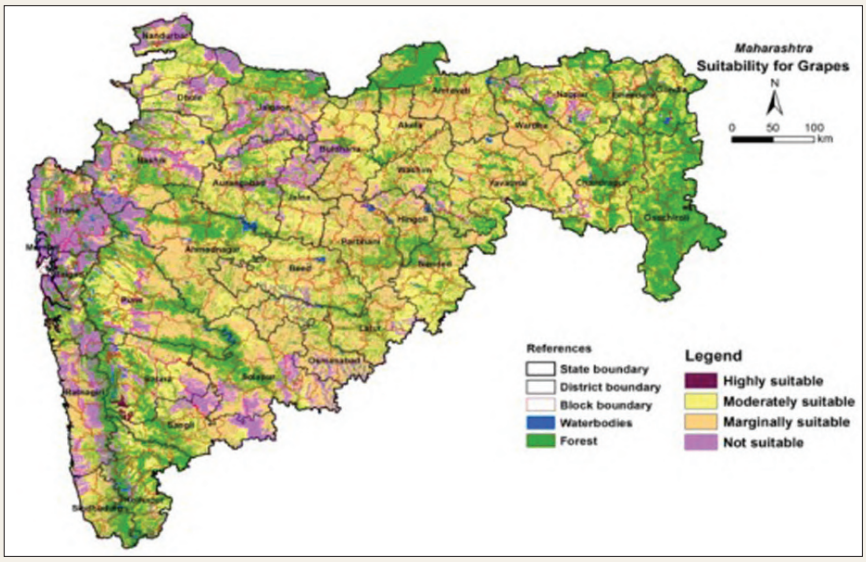
Thematic maps of soil suitability for grape growing in Maharashtra, Madhya Pradesh and West Bengal were developed in association with ICAR-NBSS&LUP, Nagpur. These maps will be useful for the identification of regions suitable for grape growing in non-traditional areas and/or explore feasibility to grow grapes for year around availability.



Soil suitability for grape cultivation—West Bengal



Soil suitability for grape cultivation—Madhya Pradesh



Soil suitability for grape cultivation—Maharashtra

A bio-consortia for agri-horticultural crops

CSR GROW-SURE is a unique bio-stimulant comprising highly efficient salt tolerant bacteria strains CSR-M-16 (*Bacillus licheniformis*), CSR-A-11 (*Lysnibacillus fusiformis*), CSR-A-16 (*Lysnibacillus sphaericus*). The formulation was assessed for growth and yield parameters in tomato var. NS 585 and banana grown in sodic soils of *p*H 9.14–9.30 and partially reclaimed sodic soils of *p*H 9.2, respectively, and found more efficient than CSR-BIO.

Tomato cultivation with application of CSR GROW-SURE at Samesi, Lucknow

(ECe), respectively, over their corresponding initial ECe values. The cut-soiler technology reduced soil salinity and increased the mustard and pearl millet yield by 13% in 2020–21 over initial year (2018–19).

Enhancing input use efficiency in papaya: Raised bed cultivation along with fertigation of 75% N, P_2O_5, K_2O + drip irrigation at 80% ER + micronutrient foliar spray of zinc sulphate (0.5%) + boric acid (0.1%) (alternate months from 2nd MAP) significantly enhanced the yield of papaya cv. Red Lady and TNAU Papaya CO 8 in Andhra Pradesh, Tamil Nadu and Bihar. The estimated yield enhancement is to the tune of 36.39 to 70.52% with a B:C ratio of 2.13 to 2.97 over the recommended practices.

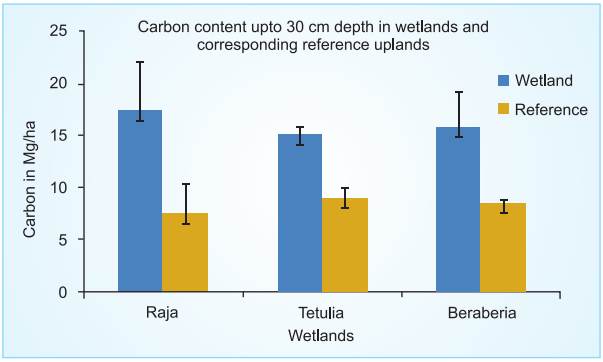
Mulching and inline drippers enhance irrigation use efficiency in oil palm: The technique of using plastic mulches in oil palm basins was standardised. Plastic mulching was effective in enhancing water-use efficiency as it recorded almost comparable yields with microjet irrigation (normal practice) when irrigated at 25% deficit irrigation in combination with normal drip and inline drip methods. Plastic mulching is effective in saving 25% water under deficit water conditions.

Salinity tolerance threshold for Thompson Seedless grafted on Dogridge rootstocks: The tolerance rate of Thompson Seedless grapes grafted on Dogridge rootstock decreased with increasing salt concentration (shoot/root dry weight basis) with 0.25% salinity level of NaCl as the threshold value and the tolerance index at 102.36 (shoot/root dry weight basis).

Soil salinity tolerance in tomato: Salinity study in tomato indicates that tomato cultivars (Kashi Aman and Kashi Adarsh) can tolerate moderate salinity (up to 6 EC) when grafted over brinjal rootstocks-IC 354557 and Surya. Tomato cultivar Kashi Aman showed 33.1 to 38.4% reduction in yield at 6.0 EC as compared to seedlings wherein 95.73% reduction in yield was noticed at 6.0 EC saline water.

❑

Wetlands as source of carbon accumulation and sequestration: Wetlands can serve as an effective C-sink in mitigating global warming. Carbon sequestration potential of the floodplain wetlands were assessed in different categories of wetlands of Assam and West Bengal. The estimated C in wetlands of West Bengal revealed higher accumulation which varied from 1.67 times (Tetulia) to 2.3 times (Raja) of the C content of their corresponding upland sites. Similarly, C deposit up to 30 cm depth of soil was also higher (1.7 to 4.2 times) than the carbon deposited in the reference upland sites in Assam.

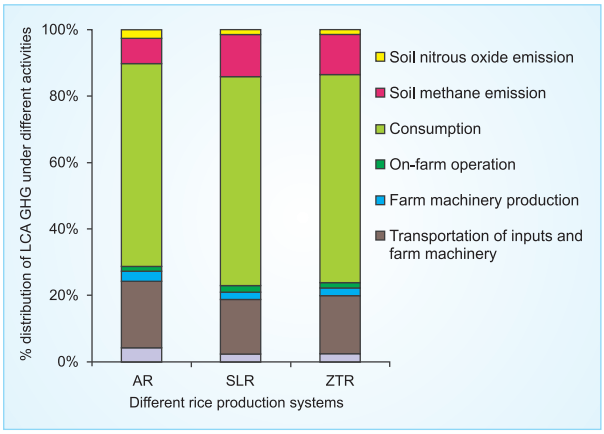


Carbon accumulation in wetlands and corresponding reference sites of West Bengal (*top*) and Assam (*bottom*)

Life cycle assessment to assess carbon footprint of major rice production system: Life cycle assessment (LCA) is a holistic approach to assess multiple environmental impact over the entire life cycle of products or services. Accordingly, carbon footprint was estimated in different rice production systems (zero-till, aerobic and shallow lowland) through total life cycle analysis. The total LCA of GHG emissions deriving from three main components, viz. cradle to farm (input production and transportation to farm), on-farm emission, and farm-gate to consumption.

The study revealed that aerobic rice emitted lowest total GHG-C-eq/tonne followed by ZTR and SLR, respectively. The carbon footprint per tonne of rice production systems varied from 0.57–0.87 t C-eq/tonne. The lowest value was found under ZTR. ZTR system saved 34.0 and 48.6% of net life cycle GHG-emission over AR, SLR system, respectively. On the other hand, soil organic carbon sequestration in rice production systems over initial value ranged from 0.41–1.9 tonnes/ha. The highest C-sequestration was recorded under ZTR and lowest in AR system. The order of C-sequestration in different systems was ZTR > SLR > AR. Emission at pre-farm (in put-production to farm) segment for AR, SLR, and ZTR was 0.26, 0.23, 0.24 t C-eq/tonne, respectively, and it was higher than the emission during the on-farm segment.

For the production of one tonne of rice, after accounting for soil C-sequestered, carbon footprint (net LCA of GHG emissions) followed the sequence of SLR > AR > ZTR. For production of one tonne of rice, the GHG emissions were 0.73, 0.76, and 0.87 t C-eq/tonne in ZTR, AR, and SLR, respectively. The total life cycle GHGs for production of one tonne of rice were 0.94, 1.18 and 1.04 t C-eq/tonne in AR, SLR, and ZTR, respectively. Of the three segments of rice production systems, viz. cradle (input production and transportation to farm), on-farm emissions, and from farm-gate to consumption; the post-harvesting segments (i.e from farm gate to consumption) contribute maximum GHG emissions to LCA followed by transportation of inputs and farm-machinery, and on-farm soil emissions. It is suggested that processing, cleaning, milling and post-harvest activities must be taken into priority to mitigate GHG emissions.



Percentage contribution of carbon footprint from different inventories for the production of one tonne of rice (AR, aerobic rice; SLR, shallow low land rice; and ZTR, zero tillage rice).

Multiple-stress tolerant rice Swarna Samriddhi Dhan for lowland ecosystem of Bihar: A multiple-stress tolerant rice variety Swarna Samriddhi Dhan (IET 24306) developed by ICAR–RCER, Patna was notified and

released for cultivation in irrigated as well as rainfed lowland ecosystems of Bihar. Swarna Samriddhi Dhan is a medium duration (135–140 days), high-yielding (5.5–6.0 tonnes/ha), multiple-stresses (drought, submergence, disease and insect pest) tolerant, lodging resistant with desirable cooking quality traits and long slender grain type. Quality wise, Swarna Samriddhi Dhan possesses 77.8% hulling, 62.0% milling, 55.6% head-rice recovery (HRR) with desirable intermediate alkali spreading value (ASV=7.0), amylose content (24.33%) with long slender grain type. Beside drought tolerant, this variety can also tolerate 8–10 days submergence.

Drought-tolerant rice Swarna Sukha Dhan for rainfed upland ecology of Uttar Pradesh: A drought-tolerant rice variety Swarna Sukha Dhan (RCPR 16, IET 24692) was notified and released for cultivation under drought prone rainfed upland ecology in Uttar Pradesh. RCPR-16 (IET 24692) has recorded yield advantage of 11.48 and 19.63% over NDR 97 (best check) and Shusk Samrat (local check) respectively. Swarna Sukha Dhan is a short duration (110–115 days), high-yielding (3.5–4.0 tonnes/ha), and multiple-stresses (drought, diseases

and insect pest) tolerant with desirable cooking quality traits. Quality wise IET 24692 showed high hulling (78.4%), milling recovery (70.9%), head-rice recovery (68.4%), medium slender grain type with intermediate amylose content (22.32%) and alkali spreading value (ASV=4.0). It has GC content (49 mm) with very occasionally chalky and medium slender grains indicating good cooking quality.

Impact of nitrogenous fertilizers on emission of greenhouse gases

Experiment in potato field showed that application of urea leads to significant increase in N_2O emissions (11–86%) over the application of ammonium sulphate. Broadcasting of urea was observed better as emission of N_2O was significantly higher (18–54%) under band placed urea as compared to its broadcasting. Although higher dose of N (270 kg/ha) significantly increased total tuber yield over 180 kg application, it also led to higher emissions.

Potato field during GHG studies at Modipuram (Meerut)

Interspecific grafting of tomato on brinjal rootstock for overcoming excess soil moisture stress: The brinjal root system is resilient to saturation moisture and survives better under water stagnation conditions. Further, the brinjal as a rootstock exhibits good graft compatibility with tomato scion. The grafting technology, employing resilient brinjal rootstock of cv. Arka Neelkanth, helps to combat excess moisture stress experienced by tomato during intensive rainy spells.The seedlings of both tomato and brinjal are raised in portrays. Splice grafting is done after 30 days of sowing tomato seeds and graft is held with plastic clips. The grafts are maintained in mist chamber for a period of 10–15 days at the temperature of 24 to 28°C, and relative humidity from 75 to 85%. Grafts are ready for transplantation in

Impact assessment of "Low Tunnel Technology" of vegetable cultivation during off season

An intensive survey was conducted in Jaipur bypass, Pemasar village, Jaipur road, Narangdesar, Sagar, Raysar, Ridmalsar, Napasar, Gardwala, Kilchu, Kalyansar, Gigasar, Ambasar, Sujasar, Palana, Swarupsar, Kolsar, Bachhasar, Meghasar, Naiyo ki Bast, Jaisalmer bypass, Ganganagr Highway, Khara, Sarahkunjiya villages and surrounding areas of Bikaner in Bikaner district to collect basic data/information about the impact of adoption of "Low Tunnel Technologies" for cultivation of vegetables during off season (winter). The study revealed that the local farmers grow various vegetables (specially cucurbits) under "Low Tunnel Technologies (LTT)" during the winter for advance production to fetch more price and earning from the vegetable market/ *Mandies*. "Low Tunnel Technologies (LTT)" for vegetable production has spread over 1,200 ha in Bikaner, Rajasthan and farmers get/earn ₹ 2–3 lakh net profit from one ha of land per season depending on type of vegetable, seed quality, climatic conditions, marketing demand etc.

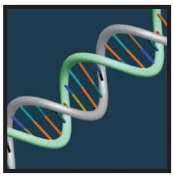
Climate change impact on livestock

An *in vivo* study was conducted to investigate the community composition of rumen methanogens in adult male cattle and buffaloes maintained on similar diet. Methanogens belonging to six orders in cattle and seven orders in buffaloes were identified. The methanogens affiliated to the *Methano bacteriales* were dominant in both the host and represented 72–73% of the total rumen archaea. There was no difference in the distribution of *Methano bacteriales* between the cattle and buffaloes. In cattle, *Methano microbiales* were the second most abundant methanogens (3.75%) and they constituted only 0.85% of the total archaea in buffaloes.

A study was conducted to assess the resilience to heat stress, and to compare differences in economically important thermo-tolerant gene expression in different indigenous goat breeds (Salem Black, Malabari, Osmanabadi, Kanni Aadu and Kodi Aadu) following their exposure to heat stress. Liver transcriptome analysis revealed superior thermo-tolerance potential of Salem Black as compared to Malabari and Osmanabadi goat breeds. Furthermore, superior climate resilience capacity of Kanni Aadu and Kodi Aadu goat breeds of South India was established by heat stress stimulation model in climatic chamber.

Interspecific grafting—A strategy for mitigation of flooding stress in tomato

the field after 20 days. The grafted plants of tomato on brinjal rootstock sustain the excess moisture (water stagnation) stress for six days and after release of the stress continue to grow and provide normal yield. However, tomato plants on their own root (ungrafted) show wilting symptoms after 24 h of water stagnation resulting in complete wilting. ❑

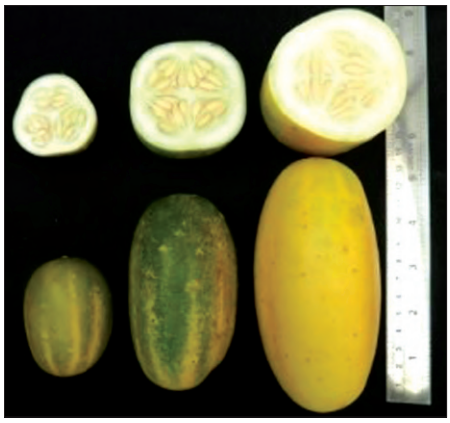


4. Genetic Resources

Plant genetic resources

Germplasm exploration: A total of 25 explorations were undertaken and 1,409 accessions (comprising 772 cultivated and 637 wild) were collected from parts of Assam, Arunachal Pradesh, Bihar, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Chhattisgarh, Maharashtra, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand and Uttar Pradesh. Geo-referencing of the collected germplasm was done in mungbean (7,172) and cowpea (6,382). The gaps for future collection were identified in states for mungbean in Bihar, Gujarat, Odisha, Maharashtra and Rajasthan and Assam, Maharashtra, Nagaland, Sikkim and Tripura in cowpea. A total of 563 herbarium specimens were processed and added to the National Herbarium of Cultivated Plants (NHCP), New Delhi bringing the holdings to a total of 24,986 specimens. Additionally, 912 virtual herbarium specimens were also processed. Germplasm accessions collected across different crop-groups were highest in vegetable, followed by cereals, medicinal and aromatic plants (M&AP), pulses and fruits with about 45% in wild species/CWR during report period.

Grain variability in bush type rajmah from Hailakandi (Assam)



Fruit variability in *Cucumis sativus* var. *hardwickii* from Uttarakhand

Some of the significant germplasm collected included landrace diversity in rice- namely deep water type *Lao Dubi, Guduli Joha, Dol Bahu, Nageri Bao, Amuna Bao, Majuli Bao, Ali Dhepa, Baoi* from Lakhimpur*; Bogi Amena Bao, Jira Joha, Haldharan, Rangi Bao, Maghuri Bao, Bangi Lohi, Moina Jaan, Kala Joha, Bora Dhan* and *Daal Kachi* from Dhimaji district of Assam; rice landraces (*Sadasarna, Kukarjali, Ranjeet saran, Kala nania, Phool pakari, Kala khudhani, Biranphool safed, Desi manshuri, Safed khudhani, Biranphool kala, Desi basmati, Jasuadhan, Khairadhan, Kaimadhan, Chanachurdhan, Samanjeeradhan, Kanakjeeradhan* and *Hapsal/Gussaddhan*) for husk colour, grain shape and size, awn, scented, early types from Araria district of Bihar; and *Borani, Dhur basmati, Kalathuni, Karmuli, Jauliadhan, Jhusiadhan, Nimuidhan, Laladhan, Pyoliadhan, Raiman* and *Uskodhan* with variability for grain size and shape, bran colour, kernel colour, stickiness, and scented types in rice from Champawat district of Uttarakahand. Natural population of guava in Pithoragarh (Uttarakhand), which is regenerating naturally in East Ramganga Valley of Uttarakhand for more than 100 years and rich population of *Cajanus cajanifolius* occurring in Bailadilla range of Dantewada (Chhattisgarh) were identified as potential sites for *in situ* conservation.

A Memorandum of Understanding (MoU) between ICAR-NBPGR, New Delhi and BSI, Kolkata was signed for exploration and germplasm collection of CWR, RET, M&AP species from forests and PAs.

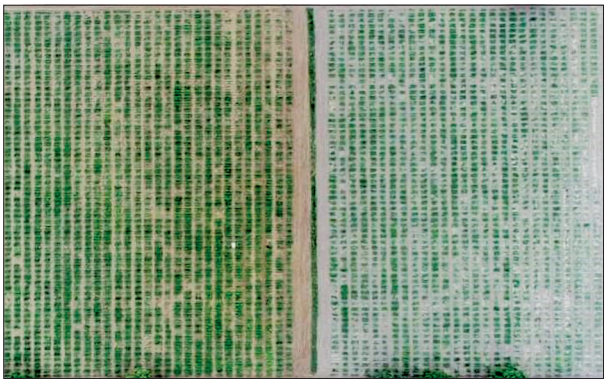
Germplasm conservation: Germplasm added to the National Genebank for long-term storage comprised 8,622 accessions of orthodox seed species and currently the base collection of National Genebank has a total of 4,56,568 accessions. A total of 16 accessions of fruits, tubers, bulbs and medicinal plants were added to the *in-vitro* Genebank, making the total collection of 1,928 accessions in the form of ~39,000 *in vitro* cultures of 54 genera and 149 species. In the Cryogenebank, 237 accessions of seeds and pollen genomic resources of different crop species were successfully cryopreserved, making the total collection of 12,076 accessions belonging to 860 species, besides 2,194 genomic resources.

Germplasm exchange: A total of 41,490 samples were imported from 36 countries. Also, 13,566 entries (1,43,850 samples) were imported in trials/nurseries from CG Centres. Important trait specific accessions that were imported are: Maize: Wild species *Z. mexicana* (EC104700-1074743) from Mexico; wild species *Zea parviglumis* (EC1084237-EC1084269) from USA; Soybean: High-yielding, conventional, late maturity

group III germplasm line that brings in new genetic diversity for potentially increasing seed yield and valuable source of new genetic diversity for soybean breeding programme (EC1075826) from USA; Sunflower: Registered cultivars possessing high acid and mutations that increase the y- and s-tocopherol level of the seed, leading to a more stable vegetable oil product (EC1079210-EC1079212) from USA; Taramira - Wild species (*Eruca vesicaria* subsp. *sativa*) (EC1085428-1085697) from USA; Crambe - Wild species *Crambe filiformis, C. glabrata, C. hispanica* subsp. *abyssinica, C. juncea, C. kralikii, C. maritima, C. tataria* (EC1085274-1085425) from USA; Lathyrus: Wild species - *Lathyrus aphaca, L. annuus, L. cicera, L. amphicarpos, L. clymenum, L. latifolius, L. ochrus, L. setifolius, L. sphaericus, L. tingitanus, L. nissolia* (EC1068321-341, 356) from Hungary; *L. annuus, L. aphaca, L. cassius, L. chloranthus, L. cicera, L. cirrhosis, L. clymenym, L. gorgoni, L. hierosolymitanus, L. inconspicuous, L. latifolius, L. nissolia, L.ochrus, L. odoratus, L. pratensis. L. rotundifolius, L. sphaericus, L. sylvestris, L. tingitanus, L. tuberosus, L. vinealis* (EC1073130-149, 153-155, 159-172, 176-191) from USA; *L. cicera (*EC1077632-698) from Australia; wild spp- *L. aphaca, L. anuus, L. cicera, L. amphicarpos, L. clymenum, L. hirsutus, L. latifolius, L. ochrus, L. setifolius, L. sphaericus, L. tingitanus* (EC1061207-1061230) from Spain; Chickpea: Wild species- *Cicer bijugum, C. echinospermum, C. judaicum, C. pinnatifidum, C. reticulatum* (1078462-1078842) from Australia; Marama bean: Drought tolerant, high nutritional value (high protein content) EC1058893 from Namibia; Cotton: Local varieties fairly drought tolerant, medium to long staple length (1058933-105895) from Uganda; Bottle gourd: Lines resistant to *Zucchini yellow mosaic virus* (ZYMV) (EC1085231-EC1085258); resistant to powdery mildew and ZYMV (EC1085231-EC1085232) from USA; Cucumber: Lines resistant to downy mildew (EC1085222-23, 28), low temperature tolerant (EC1085224), resistant to *Cucurbit yellow stunting disorder virus* (CYSDV) (EC10852270), resistant to downy mildew, resistant to *Tomato Leaf Curl New Delhi Virus* (LCNDV) (EC1085229), carotenoid rich (EC1085230); Apple: Geneva 890 and Geneva 969-semidwarfing rootstock resistant to fire blight (*Erwinia amylovora*), crown rot (*Phytopthora* spp.) and woolly apple aphid (EC1053881-882) from USA; Dwarf, semi dwarf varieties, cold hardy, resistant to crown and root rot, fire blight, powdery mildew (EC1068357-EC1068359) from USA; Saffron*:* Wild species *C. nevadesis* having rounded keel (EC1056936) from Spain; Heeng (EC 1076813-EC1076872) from Afghanistan; Avocado - Improved varieties and genetic stocks from Australia (EC1088093-1088100).

Besides this, one set each of 350 samples of wheat advanced lines and varieties were sent to Bangladesh and Bolivia for screening against blast disease, under collaborative research project. 45 samples of Dolichos (5 each) exported to African partners in Burkina Faso, Ghana, Kenya, Mali, Niger, Nigeria, Uganda, Namibia and Senegal under collaborative research project 'Evaluation of Stress Tolerant Orphan Legumes for dryland farming system across Sub-Saharan Africa and India'.

Germplasm characterization/evaluation: A total of 25,325 accessions of germplasm were characterized for agro-morphological traits at New Delhi. Agro-morphologically diverse core set is being developed in sesame, cowpea, pea, lentil and linseed. Screening against biotic and abiotic stresses in different crops was done in 8,500 and 9,215 accessions, respectively. Biochemical evaluation of 6,580 accessions was undertaken in different crops for oil content, protein, sugar, amino acids, antioxidants and active principles.

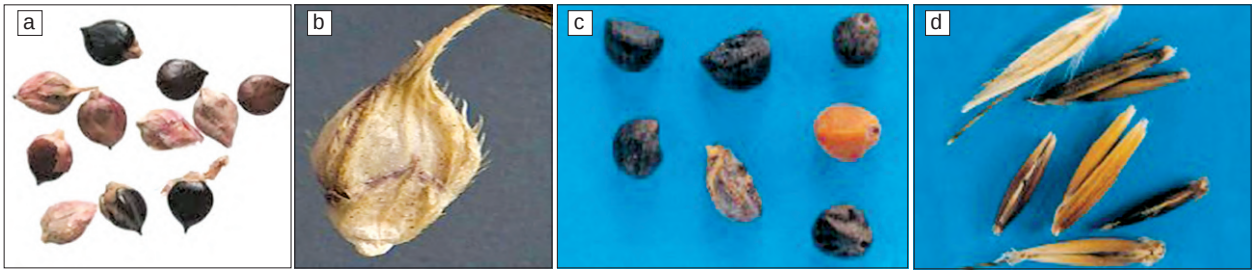


Field view of lentil phenotyping for drought tolerance under irrigated (*left*) and rainfed (*right*) conditions

Plant quarantine: A total of 1,22,736 imported samples were processed for quarantine clearance. The 7,180 samples infested/ infected with different pests. From this, 83 samples were rejected due to fungal pathogens of quarantine importance. Important interceptions included-fungi, *Phoma exigua* and *Phoma herbarum* in *Momordica charantia* from Thailand, *Tilletia barclayana* in *Oryzae sativa* from USA, *Diaporthae phaseolorum* in *Jatropha curcas* from Germany, *Bipolaris maydis* in *Zea mays* from Mexico, *Diaporthae phaseolorum, Graphium ulmi* in *Luffa acutángula* and *L. cylindrica* from Thailand, insects; *Bruchus rufimanus* in *Lathyrus* spp. from Spain; *B. dentipes* in *Vicia faba* from Lebanon and *Callosobruchus subinnotatus* in *Vigna subterranea* from Niger. Nematodes *Aphelenchoides besseyi* on *Oryza sativa* from Bangladesh, Brazil, Philippines and USA, *Aphelenchus avenae, Helicotylenchus* sp. *Pratylenchus penetrans*,

Seed health testing for pest-free conservation

A total of 12,612 indigenous samples were processed for pest-free conservation. The 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 soyabean.



Exotic weed species, *Polygonum lapathifolium* (a), *Echinochloa crus-pavonis* (b), *Convolvulus plebeia* (c) and *Avena sterilis* (d) intercepted in imported germplasm

Rotylenchus ssp and second stage juveniles of *Meloidogyne* sp. on pear and apple saplings imported from Belgium and France were also intercepted. Six viruses which are not reported from India were intercepted. Four noxious weeds (*Polygonum lapathifolium, Echinochloa crus-pavonis, Convolvulus plebeia* and *Avena sterilis*) not reported from India were intercepted. A total of 68 post-entry quarantine inspections were carried out by Plant Quarantine scientists for imported consignments at indentors' site and in virtual mode. A total of 974 samples were processed for export, by issuing 10 Phytosanitary Certificates.

DNA fingerprinting

Plants: During the period under report, 158 samples of agri-horticultural crops were DNA profiled from different public and private sector organizations. The crops in which these were profiled included paddy, wheat, barley, pearl millet, maize, oats, pea, french bean, cowpea, blackgram, greengram, horse gram, Dolichos bean, soybean, mustard, sesame, linseed, hot pepper, okra, brinjal, tomato, fenugreek, fennel, Chenopodium, and walnut. The status of total collection in National Genomic Resource Repository (NGRR) is 9,094 from 46 species (http://www.nbpgr.ernet.in:8080/NPGRR/Home.aspx) till 30 September 2021. The whole genome sequence of cardamom (*Elettaria cardamom*) variety Njallani Green Gold has been assembled at a N50 of ~151 kb with 72% BUSCO completeness. Genome wide SSR markers in cardamom have been identified, characterized, validated (136) and utilized for diversity analysis (86 accessions). GM testing services were provided for 28 samples (22 consignments) received from public/private sector. The 37 imported GM samples were tested for specific transgenic elements and to ensure absence of terminator gene technology.The scope of accreditation (ISO/IEC 17025:2017) of GM Detection Research Facility was enhanced to GM testing of oils.

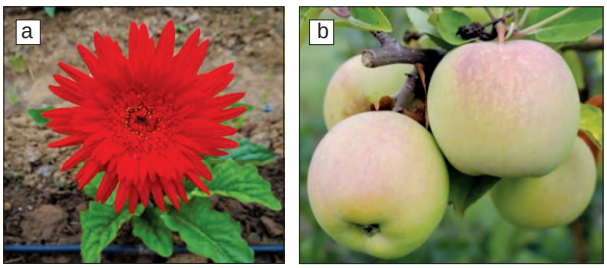
Microbes: To maintain the authenticity of biopesticides and to check the spurious and substandard products, the CIB&RC has included molecular identification and DNA fingerprint as mandatory requirement for registration and recognized ICAR-NBAIM as the nodal agency for developing DNA fingerprints of microbial cultures to be registered as biopesticides. More than 300 samples from more than 100 companies and biopesticide units under SAUs have been processed for fingerprinting at NBAIM. The samples mainly contained *Trichoderma harzianum, T. asperallum, Beauveria bassiana, Metarhizium anisopliae, Verticillum lecanii, V. chlamydosporium, Paecilomyces lilacinus, Pseudomonas fluorescens, Bacillus thuringiensis, B. subtilis,* etc.

Insects: Molecular characterization and DNA barcoding of 117 insects were carried out. The genomes of cotton leafhopper, *Amrasca biguttula biguttula,* four entomopathogenic nematodes (EPNs) and two *Bacillus thuringiensis* strains have been sequenced and assembled. In addition, mitochondrial genome sequencing of four EPNs and stage specific transcriptome sequencing of 23 insect samples have been undertaken for the study of gene functions.

Plant germplasm registration: The 42nd, 43rd and 44th Plant Germplasm Registration Committee (PGRC) meetings were conducted online through GRIS (Germplasm Registration Information System). A total of 228 proposals complete in all respect were considered for registration out of 292 proposals received. Finally, 150 proposals belonging to 79 species were approved for registration. Some notable registered germplasm were: Rice highly tolerant to sheath blight; Barley with low beta- glucan content (< 3.5%). High yield potential

Summary of trait specific germplasm registered during 2020–2021 with current status

Crop group	Germplasm registered during 1 November to 30 September, 2021	Present status
Cereals and pesudo-cereals	51	616
Millets	18	101
Fibre and forages	2	122
Grain legumes	11	170
Vegetables	11	102
Oilseeds	9	227
Commercial crops	10	114
M&AP and spices	5	106
Fruits and nuts	6	50
Tubers	4	46
Ornamentals	15	84
Narcotics	8	8
Agro-forestry	0	8
Grand total	**150**	**1,754**



Registered germplasm of (a) Gerbera: IIHRGO-1 (IC0632739; INGR20102 with Bright red (RHS colour: 40A, Red Group) and double type flowers and (b) Apple (*Malus domestica*) (IC00638609; INGR21071), germplasm resistant to Scab. High TSS and firmness.

and resistance to yellow rust; French Bean resistant to white mold disease (*Sclerotinia sclerotiorum*); Castor with high ricinoelic acid and early maturity; Papaya tolerant to papaya ringspot virus with yellow flesh; Self-Incompatible (SI) line of cabbage with flat compact head and shorter stalk length; Castor pistillate line with good combining ability; Chrysanthemum with spatulate shaped florets; Potato with better nitrogen-use efficiency.

Microbial genetic resources

The National Agriculturally Important Microbial Culture Collection (NAIMCC), designated as national repository for agriculturally important microorganisms by the National Biodiversity Authority under the National

Trait-specific germplasm registered in 2021

Crop	National identity	INGR number	Novel (unique features)
Apple (*Malus domestica*)	IC0637592	21070	Better fruit size (higher (155 g)). Early maturity (114–117 days). Better fruit quality
	IC0638609	21071	Scab resistance. Fruit quality (high TSS (18°B) and higher firmness).
Avocado (*Persea americana*)	IC0612469	21072	High yield (about 370–400 kg/plant with average fruit weight of 367–428 g). Improved fruit quality. Regular bearing behaviour.
Barley (*Hordeum vulgare*)	IC638874	21100	Resistant to stripe rust at APR under artificial inoculation in naked barley.
	IC638875	21101	Corn leaf aphid resistance
	IC638876	21102	Corn leaf aphid resistance
	IC635429	20083	Low beta glucan content (<3.5%) -malt quality trait. High filtration rate and Kolbach index (Malt Quality Traits). High yield potential and resistance to yellow rust.
Barnyard Millet (*Echinochloa esculenta*)	IC0637584	21049	Awnless panicle in the genetic background of Japanese barnyard millet species (*Echinocloa esculenta*), Semidwarf, Green glumes.
Betel leaf (*Piper betle*)	IC0629872	21076	Wavy margin in leaves. Deep concave shape leaves. Dark green leaf colour and low eugenol (27.57%) content.
Blackgram (*Vigna mungo*)	IC0636672	21051	Extra early (60–62 days). Resistant to yellow mosaic disease.
Bramhi/Indian birthwort (*Aristolochia indica*)	IC0618244	20097	Higher asiaticoside content (3.73%). Higher total triterpene content (7.67%). Higher dry biomass content (2,276 kg/ha).
	IC0618233	20098	Higher fresh biomass yield of 15 tonnes/ha/year. Higher total carotenoid (32.33 mg/100 g) and iron (149.5 ppm) content broad sized leaves with long petiole.
Cabbage (*Brassica oleracea* var. *capitata*)	IC638877	21105	Self-incompatible (SI) line. Flat compact head. Shorter stalk length.
	IC638878	21106	Self-incompatible (SI) line. Round and very compact head. Smaller plant spread and height with minimum number of non-wrapper leaves.
Carrot (*Daucus carota* subsp. *sativus*)	IC0635036 IC0635037	20115	Dark purple (black) colour, main season tropical carrot CMS line developed indigenously. It has petaloid type sterility and stable and easy to distinguish.
	IC0598343 IC0637028	20116	First red colour, main season tropical carrot CMS line developed indigenously.
	IC0635034 IC0635035	21056	Red colour, heat-tolerant tropical carrot CMS line developed indigenously. Roots are of acceptable size, red colour and self core. CMS line suitable for early season sowing due to its Pusa Vrishti (IPC HT2) genotype background
	IC0635038 IC0635039	21090	Orange colour, main season tropical carrot CMS line developed indigenously. Roots are of acceptable size and suitable for main season sowing, i.e. from mid-September onward in north Indian plains. It has petaloid type sterility and stable and easy to distinguish.
Castor (*Ricinus communis*)	IC636678	20094	High ricinoelic acid. Early maturity.
	IC0449033	21064	Resistance to leaf hopper.

(*Contd*...)

Crop	National identity	INGR number	Novel (unique features)
	IC638879	21107	Pistillate line (female line) with good combining ability. Normal plant type with elongated internodes, divergent branching, flat leaves.
Cauliflower (*Brassica oleracea* var. *botrytis*)	IC0637026	20092	Cytoplasmic male sterile line. Compact creamy white curd.
	IC0637027		Strongly waxy. Bluish-green broad leaves.
	IC0637585	21057	Resistant to black rot disease (*Xanthomonas campestris* pv. *campestris* race 1). Carry a novel single dominant gene Xca1bo for black-rot resistance. Xca1bo gene is located on chromosome 3 and flanked by DNA markers.
Chickpea (*Cicer arietinum*)	IC0633092	21052	Resistant against wilt for consecutive two years in Central and South zone. Good yield, higher or at par with the leading checks, viz. GNG 1581, GNG 2171, JG 16, GCP 101, GCP 105, KWR 108 and JAKI 9218. Early or at par with the checks GNG 1581, GNG 2171, JG 16, GCP 101, GCP 105 and KWR 108 in NWPZ, NEPZ, WCZ, ECZ and SZ.
	EC720481	21053	Resistant against *Botrytis* gray mold.
	EC720438	21054	Resistant against *Ascochyta* blight.
China aster (*Callistephus chinensis*)	IC0625184	21066	Resistance to *Alternaria* leaf spot disease. High yielding. Branching habit and late flowering type.
Chrysanthemum (*Chrysanthemum* spp.)	IC635436	20106	Yellow flower colour. Double flower shape (8.36 cm diamter). Spray type.
	IC635437	20107	Brick red flower colour with bi-coloured florets (yellow colour on floret tips). Spray type.
	IC635438	20108	Pink flower colour. Flower diameter 9.94 cm. Plant height 100.97 cm.
	IC635439	20109	Dark pink flower colour. Spatulate (Fluted) florets. Flower diameter 7.99 cm.
	IC638881	21108	Florets spatulate in shape. Long peduncle (8–12 cm).
	IC638882	21109	Flowers possess mild fragrance. The plant bears cream white coloured (RHS NN155B, White Group) ligulate type flowers.
	IC638883	21110	Spray chrysanthemum and suitable for pot mums and garden decoration. Attractive yellow coloured (RHS colour 7C- Yellow group) single type flower. Plant gives an appearance of leaflessness and dome shape during flowering.
Damask rose (*Rosa damascene*)	IC635435	20105	High flower yield 4.92 kg/plot (12 m^2).
Finger millet (*Eleusine coracana*)	IC0635026	21044	VR 1062 ranked first among all the 3,000 entries tested for neck blast resistance (2.5% Pooled data) and also showed resistance to finger blast (3.0% Pooled data). VR 1062 has recorded -37.5% and -97.41% (less incidence) of neck blast over resistant check Sri Chaitanya (VR 847) and susceptible check, Champavathi (VR 708) respectively.
	IC0403065	21045	Early flowering with 65 days as compared to the similar early maturing check VL 376 which recorded 69 days. It is also early maturing with 105 days as compared to the early maturing check VL 376 which recorded 112 days. Higher grain yield of 2,188 kg/ha as against the similar maturity check VL 376 which recorded 2,155 kg/ha.
	IC0637583	21046	White grain, blast resistant, medium maturity and high grain yield.
	IC0473958	21047	Resistant to neck blast (3.71 score in 1–9 scale).
	IC0473970	21048	Resistant to finger blast (2.9 score in 1–9 scale).
Foxtail millet (*Setaria italica*)	IC0479823	21050	Early flowering (44 days). Early duration (76 days) with desirable grain yield.
French bean (*Phaseolus vulgaris*)	EC271515	20090	Resistant against white mold disease (*Sclerotinia sclerotiorum*).
	IC278744	20091	Resistant against white mold disease (*Sclerotinia sclerotiorum*).
	IC340947	21103	Resistant to BCMV disease.
Gerbera (*Gerbera* spp.)	IC0630601	20100	Double flower shape.
	IC0630600	20101	Double flower shape. Standard size (>10 cm).
	IC0632739	20102	Flower colour and flower form: Bright red (RHS colour: 40A, Red Group) and double type flowers. Ability to grow under open field conditions.

(*Contd*...)

Crop	National identity	INGR number	Novel (unique features)
Groundnut (*Arachis hypogaea*)	IC0637587	21060	Salinity tolerant. CAM (Crassulacean Acid Metabolism) variant.
	IC0637588	21061	Salinity tolerant.
Indian mustard (*Brassica juncea*)	IC609646	20093	High temperature tolerance at seedling stage.
	I00637589	21062	High antioxidants (phenol and tocopherol). Low anti-nutritional component (phytic acid). Double low (<2% erucic acid in oil and < 30 µmoles glucosinolate/g defatted seed meal).
	IC0637590	21063	Resistant to white rust disease. Presence of two different genes conferring resistance against white rust. Good agronomic base.
Jute (*Corchorus olitorius*)	IC0503729	21035	Susceptible to stem rot disease caused by *Macrophomina phaseolina.*
Lasora (*Cordia myxa*)	IC0621779	21069	Resistance to tingid bug, *Dictyla cheriani.*
Maize (*Zea mays*)	IC0637575	21033	Improved beta carotene of 9.248 µg/g.
	IC0637576	21034	Improved beta carotene of 8.286 µg/g.
	IC0637577	21032	Tolerance to high density planting. Stable high yielding genotype with 2.29 tonnes/ha under normal density. Medium in maturity (95 days).
Marigold (*Tagetes* spp)	IC0630603	20103	High biomass yield 58.11 kg/plot (24 m^2). Essential oil content 0.343%.
	IC0630602	20104	High essential oil content: 0.375% (3.75 g/kg).
Mung bean (*Vigna radiata*)	IC639796	21104	Yellow seed coat colour. Early maturity (55 days).
Papaya (*Carica papaya*)	IC0637024	20113	Papaya ringspot virus tolerant line. Yellow flesh.
	IC0637025	20114	Papaya ringspot virus tolerant line. Yellow flesh.
Pea (*Pisum sativum*)	IC0637586	21059	Fasciation plant type. Synchronized flowering and pod formation. Putative mutant synthesised from Azad P-1.
Potato (*Solanum tuberosum*)	IC0637593	21073	Highly resistant to both the species of potato cyst nematode (*Globodera pallida* and *G. rostochiensis*). Highly resistant to late blight (*Phytophthora infestans*) and non-preference to white fly. Promising advanced clone performing well under long day conditions
	IC0637594	21074	Interspecific somatic hybrid derived clone [cv. Kufri Gaurav × somatic hybrid 'P 2' (*S. tuberosum* + *S. pinnatisectum*)] with wider genetic base. High yield combined with moderate late blight resistance.
	IC638884	21111	Better nitrogen-use efficiency than popular cultivars.
	IC0637595	21075	Highly resistant to late blight disease. Diploid wild potato species with diverse genetic base.
Rice (*Oryza sativa*)	IC635695	20080	Highly tolerant to sheath blight. Medium slender grain type. Possessing genetic background of elite cultivar Samba Mahsuri.
	IC0635012	21001	Fully exserted panicle. High number (305.31) of grains per panicle. Excellent outcrossing rate.
	IC0635013		
	IC0576152	21002	Vegetative stage drought tolerance. Prolific roots. High water-use efficiency.
	IC0330611	21003	Vegetative stage drought tolerance.
	IC0330470	21004	Vegetative stage drought tolerance.
	IC0301206	21005	Very high 1000-grain weight (50.4 g).
	IC0637545	21006	High grain zinc content 41.05 ppm.
	IC0637546	21007	Bacterial Blight Resistance with three bacterial blight resistance genes, xa5, xa13 and Xa21 pyramided in the rice cultivar PR106. Developed through Marker Assisted selection.
	IC0637548	21008	Resistance against BPH biotype 4 prevalent in India carrying the novel Brown plant hopper resistant gene BPH 34 from *Oryza nivara* acc. IRGC 104646 on rice chromosome 4.
	IC0637549	21009	Carries bacterial blight resistance gene from *Oryza nivara* acc. IRGC 81825 which gives complete resistance at the seedling and adult plant stage to *Xanthomonas* pathotype seven. The bacterial blight resistant gene Xa38 was mapped on long arm of chromosome 4 and STS marker was developed for marker assisted selection of the trait.

(*Contd*...)

Crop	National identity	INGR number	Novel (unique features)
	IC0637550	21010	IET 19339 carries three bacterial blight resistance genes which gives complete resistance at the seedling and adult plant stage to *Xanthomonas* pathotype seven. Three bacterial blight resistance genes, xa5, xa13 and Xa21, were pyramided into cv. Pusa 44 using marker-assisted selection.
	EC670488	21011	Tolerant to high temperature stress (>35°C) at reproductive stage with very high spikelet fertility particularly under high temperature stress.
	IC0637551	21012	Tropical japonica based NPT line, which is a restorer of WA cytoplasm possessing the restorer gene, Rf4, developed in the background of a popular indica rice variety Pusa 44.
	IC0638602	21013	Salinity tolerant.
	IC0298323	21014	Salinity tolerant.
	IC0394535	21015	Anaerobic germination tolerant.
	IC0591486	21016	Anaerobic germination tolerant.
	IC637547	21091	Bacterial blight resistance. Carries gene xa-45 (t) from *Oryza glaberrimma* accession IRGC 102600b on the long arm of chromosome 8 of rice. Agronomicaly good plants with apparently no linkage drag.
	IC0597237	21092	High grain protein content (12–14%).
	IC639794	21093	Tolerance to sheath blight. Resistance to neck blast and leaf blast.
	IC635696	20079	Higher culm strength in elite genetic background of Samba Mahsuri.
Sorghum (*Sorghum* spp.)	IC343586	20084	Drought tolerant.
	IC485033	20085	Low HCN content. High protein yield. High seed yielding single-cut forage genotype (Dual-purpose type).
	IC635700	20086	Resistant to foliar diseases (Anthracnose, Zonate leaf spot, leaf blight and grey leaf spot). High per day productivity for green fodder. High seed yield.
	IC635025	20087	Tolerance to shoot fly. Tolerance to downy mildew. High protein content (12.2%) and high grain yield with higher nutrient-use efficiency.
	IC0637580	21037	Advanced genetic material. High protein content (11.73%).
	IC0635028	21038	Grain mold resistance (3.8).
	IC0338975	21039	More seed weight (3.54 g) and high dry-fodder yield (9,798 kg/ha).
	IC0415833	21040	More seed weight (3.61 g) and high dry-fodder yield of 9,720 kg/ha.
	IC0415833	21041	Red grain with high tannin content of 4.51 mg CE/g. Adaptability to both *kharif* and *rabi*. High grain yield- on par with high-yielding white sorghum variety
	IC0585181	21042	Early flowering (<56 days).
	IC0637581	21043	Grain mold resistance *kharif* sorghum genotype with field grade grain mold score of 3.10 and threshed grade grain mold score of 3.53.
Sponge Gourd (*Luffa aegyptiaca*)	IC0588957	21058	Highly resistant to tomato leaf curl New Delhi virus. Good combiner and gives higher heterosis for yield and other desirable traits. Resistance is governed by single dominant gene.
Stevia (*Stevia rebaudiana*)	IC635703	20095	Large leaf size. Tetraploid stevia.
Sugarcane (*Saccharum* sp. hybrid)	IC636675	20110	Drought tolerance. Water logging tolerance.
	IC636674	20111	Drought tolerance. High relative water content under drought.
	IC0636676	21067	High cane yield (89.66 tonnes/ha) under drought condition. Lowest reduction for single cane weight under drought. High nitrogen (77.92 kg of dry biomass/kg of nitrogen). Use efficiency with *Erianthus* base.
	IC0638608	21068	High fibre (15.05%) in cane combining high sucrose (19.77%) content of commercial level.
Sunflower (*Helianthus annuus*)	IC0637591	21065	High oil content (41%).
Tagar (Indian_Valeriana) (*Tabernaemontana divaricata*)	IC0630604	20096	High fresh root biomass yield of 2.71 kg/plot (6 m^2). Essential oil content: 0.31%.
Tea (*Camellia sinensis*)	IC0636679	21085	Quality.
	IC0636680	21086	Drought tolerance.
	IC0636681	21087	Triploid.

(*Contd*...)

Crop	National identity	INGR number	Novel (unique features)
	IC0636684	21088	Drought tolerance.
	IC0636685	21089	Drought tolerance.
Tobacco (*Nicotiana tabacum*)	IC0574228	21077	High yielding caterpillar resistant sun-cured chewing tobacco.
	IC0634528	21078	High cured leaf yielding FCV tobacco somaclone with more number of longer and broader curable leaves suitable for irrigated alfisols.
	IC0638885	21079	High seed yielding chewing tobacco.
	IC0625211	21080	Low smoke tar delivering Flue-Cured Virginia (FCV) Tobacco.
	IC0637597	21081	White flower and white (cream colour) seed Flue Cured Virginia (FCV) line.
	IC0637598	21082	High solanesol (3.43%).
	IC0634529	21083	High yielding tobacco mosaic virus (TMV) resistant Flue-cured Virginia (FCV) tobacco cultivar.
	IC0634526	21084	Black shank (*Phytopthora parasitica*) resistant chewing tobacco entry.
Tuberose (*Polianthes tuberose*)	IC636677	20099	Dwarf tuberose selection (average plant height 48.49 cm) with short and straight spikes suitable for pot culture, vertical panel and other purposes.
Watermelon (*Citrullus lanatus*)	IC633085	20117	Saffron coloured flesh with high carotenoid content. Non-lobed (entire) leaves
Wheat (*Triticum aestivum*)	IC633420	20082	Early maturity. High yielding.
	IC0637552	21017	Resistant to wheat blast disease.
	IC0637553	21018	Novel leaf rust resistance. *Aegilops markgrafii* introgression.
	IC0637554	21019	Leaf rust resistance. *Triticum militinae* introgression.
	IC0637555	21020	Leaf rust resistance. *Triticum militinae* introgression.
	IC0638605	21021	Heat and drought tolerance.
	IC0637557	21022	Heat tolerance. Better Heat susceptibility index over check.
	IC0637558	21023	High water-use efficiency.
	IC0637559	21024	New CMS (A) line in DBW17 background with CMS source (Chuan 18A) along with maintainer (B) line.
	IC0637560		
	IC0637561	21025	New CMS (A) line in DBW 16 background with CMS source (Chuan 18A) along with maintainer (B) line
	IC0637562		
	IC0637563	21026	New CMS (A) line in PBW 502 background with CMS source (Chuan 18A) along with maintainer (B) line
	IC0637564		
	IC0637565	21027	New CMS line in DBW 55 background with CMS source (Chuan 18A) along with maintainer (B) line
	IC0637566		
	IC0637567	21028	New CMS (A) line in CBW 38 background with CMS source (Chuan 18A) along with maintainer (B) line
	IC0637568		
	IC0638603	21029	New CMS (A) line in DBW 76 background with CMS source (Chuan 18A) along with maintainer (B) line.
	IC0638604		
	IC0128565	21030	Resistant to leaf rust.
	IC0128638	21031	Resistance to leaf rust and yield stability across the locations.
	IC638868	21094	Drought tolerance.
	IC638869	21095	Leaf rust resistance (LrT) and gluconess (IwT).
	IC0638873	21096	Resistant to powdery mildew. Two powdery mildew resistance genes PmTb7A.1 and PmTbA.2 mapped on chromosome 7AL.
	IC252458	21097	Consist of three minor/adult plant rust resistance genes (APR) for leaf rust, Lr34+ (Lr34/Sr57/Yr18//Pm38/Ltn1), Lr46+(Lr46/Sr58/Yr29/Pm39/Ltn2) and Lr67+ (Lr67/Yr46/Sr55/Pm46/Ltn3) which is linked to stem, stripe and powdery mildew resistance genes. Resistant to the prevailing leaf rust pathotypes of India due to the synergistic combination of minor leaf rust resistance genes. Presence of leaf tip necrosis (LTN) on the flag leaves, a phenotypical marker that is linked to adult plant resistance (APR) genes.
	IC290150	21098	Consist of three minor/adult plant rust resistance genes (APR) for leaf rust, Lr34+ (Lr34/Sr57/Yr18//Pm38/Ltn1), Lr67+(Lr67/Yr46/Sr55/Pm46/Ltn3) and Lr68 which is linked to stem, stripe and powdery mildew resistance genes. Resistant to the prevailing leaf rust pathotypes of India due to the synergistic combination of minor leaf rust resistance genes. Presence of leaf tip necrosis (LTN) on the flag leaves, a phenotypical marker that is linked to adult plant resistance (APR) genes.

(*Contd...*)

Crop	National identity	INGR number	Novel (unique features)
	IC279875	21099	Consist of two minor/adult plant rust resistance genes (APR) for leaf rust, Lr34+ (Lr34/Sr57/Yr18//Pm38/Ltn1) and Lr68 which is linked to stem, stripe and powdery mildew resistance genes. Resistant to the prevailing leaf rust pathotypes of India due to the synergistic combination of minor leaf rust resistance genes. Presence of leaf tip necrosis (LTN) on the flag leaves, a phenotypical marker that is linked to adult plant resistance (APR) genes.
	IC633421	20081	Early maturity, High yielding.
Wild bean (*Phaseolus* spp.)	IC0259504	21055	High protein content (9.5%) in tuber. Bold seeded. Fodder type.
Wild jute (*Corchorus tridens*)	IC0637579	21036	Highly resistant to stem rot caused by *Macrophomina phaseolina*
Wild lentil (*Lens culinaris*)	EC718515	20088	Resistant against rust (*Uromyces fabae*) and powdery mildew (*Erysiphe trifolii).*
	EC718266	20089	Resistant against rust (*Uromyces fabae*).
Wild sugarcane (*Saccharum spontaneum*)	IC636673	20112	High harvestable biomass. High fibre content.

Biodiversity Act, 2002 has been conferred the status of International Depositary Authority (IDA) under the Budapest Treaty by the World Intellectual Property Organization (WIPO) in 2020. At present, the total number of holdings in NAIMCC is 7,385 (Bacteria-2864, Fungi-4174, *Cyanobacteria*-347). During the period under report, 107 agriculturally important microbial cultures were accessioned which includes 253 bacteria, 79 fungi and 4 cyanobacteria. The new microbial species introduced to NAIMCC include 58 bacteria, 5 fungi and 6 cyanobacteria. *Orrelladio scoreae, Rhizobium binae, R. multihospitium, Sinomona satrocynae, Pseudo-arthrobacter niigatensis, Halomonas sulfidaeris, Kribella karoonensis, Lutoibacter jiangsuensis, Nocardiopsis flavescens, Sarocladium implicatum, Setosphaeria rostrata, Lichtheimia hyalospora, Themosyne chococcus elongates, Chroogloeocystis siderophila* represent some of the newly introduced microbial species. Seventeen microbial cultures used in agriculture and in particular as biopesticides were deposited by public and private institutions under safe deposit. About 227 cultures were supplied to both academia and industry.

Description of new species: A moderately halophilic, Gram negative, aerobic bacterium belonging to the genus *Halomonas* was isolated from soil of Pentha beach, Odisha. Based on the phenotypic, chemotaxonomic and phylogenetic characteristics, strain D1-1T represents a novel species in the genus *Halomonas* for which the name *Halomonas icarensis* sp. nov. have been given.

Insect resources

ICAR-National Bureau of Agricultural Insect Resources (NBAIR) is mandated for the collection, cataloguing and conservation of insects and related organisms of agricultural importance like mites, spiders and nematodes associated with arthropods covering all the agro ecosystems of the country. The National Insect Repository located at ICAR-NBAIR is recognized by Ministry of Environment, Forest and Climate Change, Government of India as the National Repository for agriculturally important insects, spiders and mites under the Biological Diversity Act, 2002 on 12 September 2012.

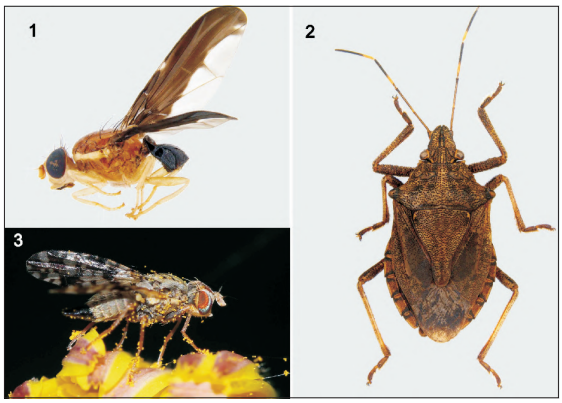
During the period (2020–21), 2,846 insects were collected and curated. A total of 91,676 dead insect specimens are being maintained at the National Insect Repository of ICAR-NBAIR. One new genus and 44 new species of insects described. New records for India includes 10 genera and 10 species of insects. The invasive mealybug, *Phenacoccus manihoti* (Pseudococcidae: Hemiptera) has been recorded in cassava for the first time and it poses severe threat to cassava production in India. To manage the pest, ICAR-NBAIR has imported a parasitoid wasp, *Anagyrus lopezi* (Encyrtidae: Hymenoptera) from the Republic of Benin. New

Micro Veda: A comprehensive web-based system for agriculturally important microbes

A comprehensive web-based system for agriculturally important microbes namely www.microveda.org.in developed by ICAR-National Bureau of Agriculturally Important Microorganisms is an unique database having information on the collection of microbes important to agriculture and allied sectors in India, their geo-location, characteristics and importance, etc. Also the database attempts to incorporate the location based searching; Microbial Database Search (MIDAS); Knowledge models of microorganisms and trait wise listing of elite microbes at NAIMCC.

databases published online includes, "Vespids of India" and "Amazing creatures: Myths and facts".

Apart from museum specimens, 136 species of live insect germplasm comprising 107 parasitoids, 15 predators, 13 host insects and one detritivorus insect are being maintained and supplied to different stakeholders. Eighty one isolates of insect derived resources (insect pathogenic microbes) were isolated and evaluated for their entomopathogenic potential on different insect pests. A total of 850 microbial strain comprising *Bacillus thuringiensis*, nuclear polyhedrosis virus, entomopathogenic fungus and plant disease antagonists are being maintained in the repository. The EPN repository at ICAR-NBAIR is enriched with 125 strains of EPN.



New species described
1. *Hemilea totu*; 2. *Sarjubrevi rostrata*; 3. *Campiglossa sherlyae*

HORTICULTURE

Collection/Augmentation of germplasm

Indigenous sources

In fruits, germplasm in various crops such as banana (18), citrus (5), guava (3), mango (30), jamun (1), rose apple (5), jackfruit (40), pine apple (7), avocado (53) and one each in acid lime, ber, custard apple, guava, wood apple were collected.

In plantation crops, a total of three new germplasm accessions of arecanut were collected.

In vegetable, germplasm in various crops such as chilli (24), brinjal (3), water melon (3), muskmelon (5), okra (27), Dolichos bean (17), onion (3), radish (10), bitter gourd (6), ridge gourd (3), cucumber (60), cluster bean (2), bottle gourd (8), bell pepper (16), drumstick (77), curry leaf (17), summer squash (33), amaranth (9), arid zone vegetables such as chilli, cluster bean, Dolichos bean, drumstick, jhar karela, onion, spine gourd, vegetable cowpea and yellow tomato **(**45) were collected.

In flowers, germplasm in various crops such as tuberose (1), gladiolus (12), gerbera (16), dahlia (30); and in medicinal plants germplasm in crops such as gudmar G*ymnema sylvestre (*31), brahmi *Bacopa monnieri* (71), bhringaraj *Eclipta alba* (53) and mushroom (2) were collected.

Potato: A total of four new indigenous germplasm accessions of potato were collected such as, Shalimar Potato 1, Shalimar Potato 2 and Gurej local from Kashmir and Phulbani local from Bhubaneshwar.

Spices: A total of 158 germplasm accession in spices such as large black pepper (47), cardamom (4), turmeric (5), ginger and other Zingiberacious spices (36) and small cardamom (1), 14 nutmeg, 12 cinnamon, 17 clove, 19 *Garcinia*, 2 all spice and 1 vanilla were collected.

Mushrooms: A total of 439 mushroom specimen collections were made and a total of 358 specimens/ cultures deposited at the National genebank at ICAR-DMR, Solan with passport data. Further, accession numbers were given to 139 cultures.

Some specimens collected by different centres of AICRP-Mushroom

Exotic sources

Fruit crops: A total of 19 banana from International Transit Centre, Belgium; seven grape germplasm accessions (EC-772086, EC-772108, EC-772080, EC-772094, EC-772072 and Black Ferdeina) from ICAR-NBPGR, Shimla, Himachal Pradesh were received.

In addition, eight exotic grape accessions were received from M/s Golden Harvest Fruit Genetics LLP, Nasik (through EXIM Policy, GOI) with codes 1501, 1872, 349-72, 1530, 1570, 1670, 1324, 1553.

Vegetable crops: A total of three germplasm were collected from exotic sources such as pea (Edible poded) from USA, long melon from France and cauliflower from NBPGR (through ICAR-NBPGR).

Potato: A total of 37 cultures with traits suitable for processing were imported from The Netherlands (29) and USA (8).

Characterization and Identification of germplasm

Fruit crops

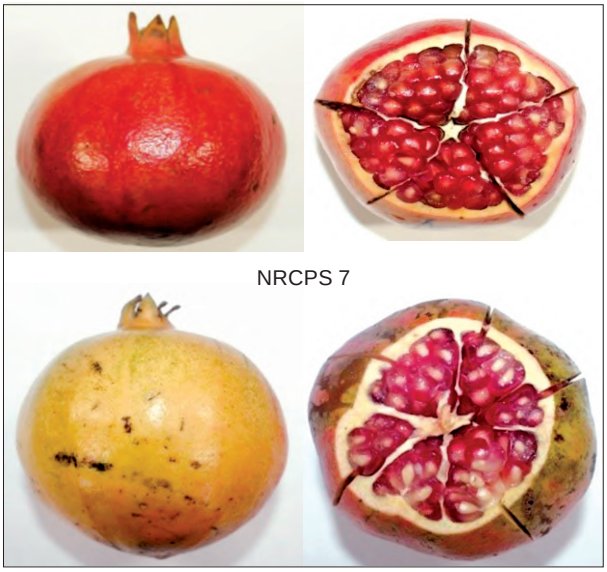
Identification of Fusarium wilt Race 1 (VCG 0124) resistant banana Cavendish accessions: Identified one Grand Naine (bunch weight 30 kg) mutant (NRCBGNM

01) and four more yielding Cavendish accessions (namely Chinese Cavendish (Acc. No. 1664), William (Acc. No. 0645), ITC 180 and Manjahaji (Acc. No. 0017)) exhibiting resistance to Foc Race 1.

Identification of Pro Vitamin A (PVA) rich banana accessions: Two dessert hybrids plantain (NOP 45–102 µg/g of Dw pulp) and Pisang Awak (Progeny No. 434-90 µg/g pulp dry weight) back grounds and one selection (ITC 2390/2) having more provitamin-A (82 µg/g of pulp dry weight) were identified.

ITC 2390/2 | NOP 45 | Progeny No. 434 | Progeny No. 932

Pomegranate: One promising wild genotype (IC-318718) for fruit cracking resistance was identified in preliminary field evaluation.



NRCPS 7

NRCPS 23

Pomegranate accessions

IC-31871: In addition, based on preliminary field evaluation, three promising genotypes of pomegranate such as, PS 7, PS 8 and PS 23 with desirable (279 to 382 g) fruit weight were identified.

Plantation crops

Oil palm germplasm with high fresh fruit bunch yield: Three high yielding dura palms (female parent), viz. palm no. 420 (FFB yield- 282.65 kg/palm/year, 18 bunches, bunch weight- 15.7 kg), palm no. 271 (FFB yield- 198.35 kg/palm/year, 14 bunches, bunch weight- 14.16 kg), palm no. 273 (FFB yield- 186.32 kg/palm/year, 12 bunches, bunch weight- 15.52 kg) were identified.

Cashew: One trait-specific cashew germplasm RFRS-195 identified having low CNSL (13.01%) in

High yielding oil palm germplasm

tender green shell with bold kernel (2.65 g – 3.10 g). Because of ease to remove shell of tender nut and less cashew nut shell liquid content, it has been observed suitable for vegetable purpose.

Oil palm germplasm with high fresh fruit bunch yield and short stature

The following elite genotypes were identified:

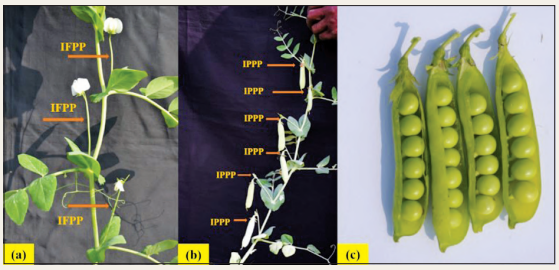
IC061001-60, Dura genotype with short stature (28.9 cm), more FFB yield (243.91 kg) and 13 bunches.

IC060051-71, Dura genotype with more FFB yield (261.71 kg) and 16.66 bunches.

IC061001-59, Tenera genotype with low annual height increment (25.25 cm) and more FFB (211.33 kg) yield.

VRP Sel-17, a pea genotype bearing single flower per peduncle on all the floral nodes

The genotype exhibited consistent flowering behaviour of single FPP on all the reproductive nodes. It is also resistant to powdery mildew and rust under natural field conditions. Despite its low pod yield (60–70 g/plant), this genotype can be used in a variety of genetic studies, including inheritance of flower numbers, flowering time, peduncle traits, seed and pod characters, disease studies, and so on.



VRP Sel-17: (a) Single flower per peduncle, (b) Single pod per peduncle, and (c) Seed filling in pods

Pea genotypes resistant to powdery mildew: Two exotic collections from late maturity groups of peas, viz. EC 865944 and EC 865975 were observed immune to powdery mildew under controlled as well as natural field screening over the period of three years with 0 PDI score.

(a) Resistant genotypes 'EC 865944' and 'EC 865975'; (b) Grown with susceptible genotype under huge disease pressure in natural field conditions

Okra: Okra genotype VRO 146 is resistant to YVMV and OELCV virus. More yield potential (170–175 q/ha), semi-dwarf (100–106 cm), dark green fruit colour, free from ring formation and easy to harvest.

Okra genotype VRO 208 is resistant to YVMV and OELCV virus. More yield potential (160–170 q/ha), medium tall (120–130 cm), dark green fruit free from ring formation and easy to harvest.

VRO-146 VRO-208 VRO-210

VRO 210 is resistant to YVMV and OELCV virus. More yield potential (160–165 q/ha), semi-dwarf (100–110 cm), dark green fruit colour free from ring formation and easy to harvest.

Muskmelon: The genotype VRMM 41 is a green fleshed genotype having average fruit weight (850 g), number of fruits/plant (2–4), yield/plant (3.7 kg) and TSS (11°Brix).

Tuber crops

Potato: Three germplasms were identified and registered with ICAR-NBPGR, New Delhi.

MCD 24 (INGR 21075) potato wild species clone: MCD 24 (*Solanum microdontum*; Accession number: PI 218224) is highly resistant to late blight. This accession is diploid with diverse genetic base.

MSH/14-129 (INGR 21074) potato hybrid: MSH/14-129 is inter-specific somatic hybrid-derived clone [cv. Kufri Gaurav × somatic hybrid P 2 (*S. tuberosum* + *S. pinnatisectum*)] with wider genetic base. The hybrid has moderate late blight resistance.

SM/11-120 (INGR 21073): It is highly resistant to both the species of potato cyst nematode (*Globodera rostochiensis* and *Globodera pallida*), resistant to late blight (*Phytophthora infestans*) and showed resistance/non-preference to white fly. The hybrid has been developed through bi-parental crossing between CP 2379 and Kufri Himalini. Molecular markers data also supported its resistance to PCN as the hybrid showed resistant band for *H1* gene specific to *G. rostochiensis* and *Gpa2QTL* markers specific to *G. pallida*.

Tropical tuber crops: A tall dasheen type taro with 10–12 kg/plant tuber yield has been identified.

Flowers

Tuberose: Sahyadri Vaman, a dwarf tuberose (plant height 48 to 52 cm) genetic stock was identified and registered with NBPGR pot culture, terrace/roof gardening, vertical panels, landscaping (bedding) besides vase decoration as cut flower (6–7 days of vase life).

Sahyadri Vaman—a dwarf genetic stock of tuberose

Spices

Black pepper: In black pepper, five accessions, viz. Acc 6709, 6611, 6718, 6728, and 6668 accessions were characterized for more dry matter recovery (> 40%).

Cardamom: In cardamom IC 349343 is a promising line for high essential oil (9.44%).

Ginger: In ginger Acc. 838 had more essential oil (4.3%), gingerol (1.92%) and shogaol (0.55%) content.

Turmeric: In turmeric, five germplasm accessions, viz. Acc. 14, 179, 214, 379 and 1545 were characterized for long and bold primary rhizomes.

Nutmeg: In nutmeg, Acc. 505, 511, 530, 572, 616 and 625 were observed to be high yielder.

Garcinia: In Garcinia, Acc. 10, 13, 14 and 20 were observed to be promising for more productivity and enhanced dry recovery.

Fenugreek: A total of three accessions of fenugreek (HM 257, HM 273, HM 293) resistant to powdery mildew and another accession (HM 444) as resistant to both downy and powdery mildew diseases were identified.

Coriander: A small seeded, leafy type coriander DH 266 resistant to stem gall disease has been identified.

Mushrooms

Trait specific germplasm identified: One low spore strain of button mushroom was developed. The yield of the sporeless strain had 65% biological efficiency.

Livestock genetic resources

Gazette notification of newly registered breeds

Gazette Notification provides statutory recognition, thereby becomes important for claiming sovereignty over and protecting our native germplasm. The Gazette notification for the native livestock and poultry breeds was initiated by the Ministry of Agriculture and Farmers Welfare, Government of India in October 2019.

Registered breeds of Rajapalayam, Chippiparia and Mudhol Hound dog; Dharwadi and Manda buffalo were notified by the Government of India [Gazette Notification: Ministry of Agriculture and Farmers' Welfare, No. 3589 (S.O.4086(E)) (November 13, 2020) and No. 3839 (S.O.4174(E)) (October 8, 2021)]. Till date 202 registered breeds of livestock, poultry and dog species have been gazette notified that includes: Cattle 50; buffalo 19; goat 34; sheep 44; horses and ponies 7; camel 9; pig 10; donkey 3; yak 1; chicken 19; duck 2; geese 1; and dog 3.

Registration of two native buffalo breeds

Dharwadi buffalo (Accession number: INDIA_BUFFALO_0800_DHARWADI_01018): Dharwadi buffalo is distributed in 13 districts of Karnataka. It is a medium size buffalo, reared mainly for milk purpose (Daily milk yield, 1.5 to 8.7 litre); average milk fat 6.9%. The milk is used for preparation of famous *Dharwad Peda* with GI tag.

Manda buffalo (Accession number: INDIA_BUFFALO_1500_MANDA_01019)**:** Manda buffalo is distributed in Koraput, Malkangiri and Nawarangapur districts of Odisha. It is a sturdy buffalo, well adapted to hill ranges of Eastern Ghats and plateau of Koraput region of Odisha and is reared for draught, milk and manure. Daily milk production ranges between 1.2 to 3.7 kg with average milk fat as 8.4.

Morphological characterization

Monyul cattle: Monyul cattle of Tawang and West Kameng districts of Arunachal Pradesh was characterized. Monyul cattle are reared by the Monpa community for milk, manure, and draught and are smaller than Siri cattle of Sikkim. The coat color is generally black but shades of brown are also present; white patches may also be present in some animals specifically on the head, legs, and lower abdomen. Body covered with thick hair coat; hairy tail reaching well below the hock; horns small to medium size, pointed forward; hump visible in adult males. Monyul cows generally produce 2 to 3 kg milk in a day.

Native buffaloes of Tripura: Bhangor buffaloes of Tripura are medium-size swamp type (48 chromosomes) generally grey to greyish-black with brown hairs. The horns are very long, curved and sickle-shaped with a flat broad base. Buffaloes are primarily reared for draught power. Milk yield varies between 1.5 and 2.5 litres/day.

Native cattle of Manipur: Manipur cattle are small and sturdy with compact body. There is great demand for the bullocks for draught purpose. The body is brown, reddish, black, grey and white spotted on black or brown color body; horns grow upward, outward and curve anteriorly; poll prominent in Manipuri cattle; hump moderate in bulls, but small in cows.

Nagavali sheep: Nagavali is mutton type sheep, distributed in north coastal districts of Andhra Pradesh. Named after Nagavali river, this sheep is also known as Karella. The animals are medium size, white coat with black patches around eyes, ears, neck, perineum and lower extremities; females polled, males horned; ears pendulous. The average adult body weight ranges from 28 to 54 kg in males and 20 to 38 kg in females.

Phenotypic characterization

Native cattle breed: Multivariate analysis was carried out for different biometric traits of 3,282 cattle of 21 native cattle breeds/populations of the country. Dendogram based on *Mahalanobis* distances revealed the grouping of different cattle breeds; importantly – Kankrej, Sanchori and Nari breeds formed a distinct group; similarly, Mewati, Hallikar and Bargur; Gangatiri, Red Sindhi and Red Kandhari; Jhari and Pullikulam; and all north-east cattle, Badri and Konkan Kapila clustered in distinct groups. About 70% of total variance component was attributed to face biometry. Such differentiating traits may be used for developing image-based programs for discriminating native cattle breeds.

Native sheep and goat breeds: Various morphometric data on 22 sheep breeds/populations and 14 goat breeds/populations were analyzed by using multivariate analysis techniques. Tail length was found to be the most differentiating trait followed by height at withers for sheep breeds. Muzaffarnagri and Munjal sheep were clustered together, however, wider apart from all other sheep breeds. Marwari was the most correctly assigned sheep breed in discriminant analysis. In goats, height at withers was the most discriminating trait followed by tail length and chest girth. Sumi-Ne goat of Nagaland clustered apart from all the goat breeds and also the most correctly classified.

Donkeys: Donkeys of Braj region of Uttar Pradesh are distributed in Mathura and Agra districts. Majority of the donkeys are predominantly of grey type, admixed with the donkeys of brown type. Morphometrically, significant differences were observed on comparison with Spiti and Sindhi donkeys as well as donkeys of Andhra Pradesh. The dendrogram revealed the clustering of the Braj donkeys independently from these three donkey populations, indicating the genetic distinctness of this donkey population.

***Ex-situ* conservation of AnGR**

Germplasm repository at National Gene Bank, ICAR-NBAGR, Karnal is being strengthened by preserving diversified form of germplasm (semen, somatic cells and DNA). Total 10,030 semen doses of native breeds (Sahiwal cattle, Nili Ravi buffalo, Marwari, Manipuri, Zanskari horses and Halari donkey) and 970 somatic cell doses of native breeds (Tharparkar cattle, Sirohi and Rohikhandi goat, Mewari, Jalori and Marwari camel and Ghurrah pig) were added during the period for cryopreservation. At present, National Gene Bank repository has 47 native breeds/ populations of livestock and poultry in semen form, 20 in somatic cells form, and 169 in DNA form.

Further, genetic diversity of cryopreserved semen of cattle bulls of 19 breeds available at the National Gene Bank was established using 17 microsatellite markers. The highest observed heterozygosity was reported in Red Kandhari, while the lowest in Amrit Mahal cattle. Haryana cattle showed the highest expected heterozygosity.

Designing of SNP Chip for native livestock and poultry

Goat: Indigenous goats (15 breeds) belonging to

diverse agro-ecological regions were sequenced for whole genome re-sequencing. More than 6 lakh informative SNPs were selected for chip designing. The identified SNPs were validated by genotyping of 480 animals of 26 Indian goat breeds, with an overall call rate of 99.8%. A patent application was filed for the high density chip for Capra hircus (Application No. 202011057422).

Sheep: Whole genome re-sequencing data generated for 20 geographically diverse, indigenous sheep breeds/ populations was analyzed and more than 300 million SNPs were identified. After stringent quality controls, more than 6 lakh SNP markers were selected for tiling on the array. HD SNP Chip for the sheep was designed.

Other species: Whole genome sequencing of the native breeds of chicken, dromedary camel and Bactrian camel, pigs, horse, dogs, yak, donkey and duck, was carried out. Data was generated with 10 X coverage of the genome with approximately 95–100 million paired end (2×150 base pair) reads per animal. The DNA chips for chicken, camel, pig, and yak was designed. Patent application for the chip of chicken and camel has been filed.

Pig

Pig genetic resources: Ten indigenous pigs were registered and nine crossbred varieties developed. Complete mitochondrial genome of six native breeds, one non-descript, three crossbred and one wild pig were sequenced, and submitted to NCBI. Microsatellite markers (30) were tested to comprehend the uniqueness of these pigs. The ancestral analysis showed that populations of indigenous pigs have distinct and well-structured lineages, and are different from other pig breeds.

Poultry

Transgenic chicken: The PGC mediated method of transgenesis was standardized to produce transgenic chicken. The PGCs were characterized with alkaline phosphatase staining, PAS staining and immuno-cytochemistry. PGCs were transfected with recombinant GFPpACGFP1-C1 construct and transplanted to the recipient sterile embryos. A total of 3 positive live transgenic chicks were produced where percentage of obtaining live positive birds was 8.3.

Gene knock out chicken: The CRISPR/Cas9 tool was used to create targeted mutagenesis of both the exons of the inhibin α gene in chicken. The mutation was successfully appreciated. The expression of edited group of cells of exon1 and exon 2 was 7.12 and 5.47% lower, respectively in comparison with the control group of cells, thus validating the mutagenesis.

Gene silencing for reducing serum cholesterol in chicken: Gene silencing by RNAi was adopted to produce knock-down chicken. The knock down birds showed 20.2 and 24.8% lower serum cholesterol and triglycerides content as compared to normal birds. In ACACA (acetyl Co-A carboxylase type A) knock down, the alkaline phosphatase increased by 13.5% in the knock down group, while SREBP-1 (sterol repeat element binding protein 1), gene knock down, 54% reduction in alkaline phosphatase activity was observed. All the knock down birds of first generation for both ACACA and SREBP1 genes were females, which were used further as female parents for back crossing with control broiler birds as male parents to produce back cross progenies. Finally, two positive knock down chicks, where shRNA constructs were detected, were hatched.

Cryo-bank established for primary somatic cells of elite buffaloes

In view of the importance of buffalo breeds, a somatic cells bio-bank was established at ICAR-CIRB, Hisar. The bank maintains finite somatic cell lines derived from tail-skin biopsies of 26 elite male and female buffaloes of three breeds including cloned animal somatic cells. The informative data such as buffalo details (breed, date of birth, sex, and age at the time of tissue biopsy collection, and production traits), the number of cryovials stored, and freezing dates were recorded in an electronic file and a printed inventory record. Cryopreserved 1,350 cryovials (0.1 million cells per vial) from Murrah and Nili-Ravi for future applications.

Fish

Description of new fish species

- A new species of snake eel, *Xyrias anjaalai* sp. nov. (Anguilliformes: Ophichthidae) was described from morphological analysis of 12 specimens and molecular analysis of four specimens, caught off Kollam, Kerala, South-Western India by deep-sea trawling. The specimens were obtained from the bycatch of deep-sea shrimp trawlers operating at a depth of approximately 290 to 347 m off Kollam.

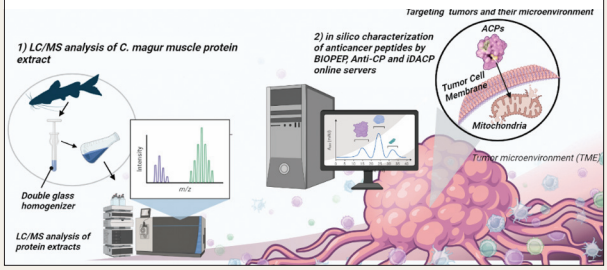
(a) *Badis kaladanensis*, holotype, ZSI FF 5404, 48.6 mm SL; (b) Paratype, PUCMF 15002, 45.2 mm SL.

- *Badis kaladanensis*, a new percoid fish (Teleostei: Badidae), was recorded and described from the Kaladan basin of Mizoram state of Northeast India. The species is distinguished from its

Bioactive peptides from fish muscle

Angiotensin Converting Enzyme (ACE) inhibitory bioactive peptides were mined from the muscle proteome of catfish, *Clarias magur*. Out of total 468 common peptides, 23 peptides showed bioactivity for ACE inhibition. ACE inhibitors help in the reduction of hypertension by effectively reducing vasoconstriction. Traditionally synthesized compounds used for ACE inhibition pose side effects. Moreover, anti-cancer peptides were also retrieved from the muscle proteome. Total 60 peptides showed anti-cancer activity. These anti-cancer bioactive peptides are exhibiting anti-tumour activity by activating apoptosis in mitochondria slaying tumour cells. The fish-derived bioactive peptides can prove to be a natural and less toxic therapeutic source.

Bioprospecting anti-cancer peptides (ACPs) from proteome of muscle tissue from Indian walking catfish, *Clarias magur* (Hamilton 1822) by mass spectrometry approach



congeners with respect to the combinations of morphological characters. The analyses of mitochondrial genes, viz. cytochrome c oxidase I (COI) and cytochrome b (cyt b) revealed the distinctness of the species from other *Badis* species (interspecific distance ranged from 5.4–20.4% for COI and 5.1–26.3% for cyt b. The species is registered in ZooBank, the official registry of Zoological Nomenclature, and got the following Life Science Identifiers (LSIDs) urn:lsid: zoobank.org:act:4D86FCA2-EEEB-43A1-B20F-A0C2884D96D6. Type specimens were submitted to the Zoological Survey of India (ZSI).

Identification of hub genes in *Catla catla:* A total of 1,677 differentially expressed genes (DEGs) were identified in three different growth stages of *C. catla* through transcriptome analysis. Fourteen differential expressed regulatory hub genes for growth were also identified for the first time. These regulatory genes are involved in myofibril assembly, morphogenesis, skeletal muscle tissue and organ development, unfolded protein binding, ribosome biogenesis, rRNA processing and metabolic process. The regulatory hub genes, except acta1, were found to be upregulated in fast-growing table size fish and post-winter fingerling groups. These results provide valuable information about the key genes to be used as biomarkers of growth in breeding programmes and contribute to our understanding of the molecular mechanisms and pathways regulating growth, in response to temperature fluctuation and different growth stages. ❑

5. Crop Improvement

Crop varieties released and notified

Since 1965, 5,587 improved field crops varieties have been developed which include 2,777 of cereals, 933 of oilseeds, 1,030 of pulses, 210 of forage crops, 460 of fibre crops, 134 of sugarcane and 43 of potential crops. During 2020–21, a total of 254 varieties/hybrids including 35 special traits varieties were notified and released for commercial cultivation. Details are given below.

Cereals

Eighty eight high-yielding varieties/hybrids of cereals comprising 39 of rice, 19 of wheat, 19 of maize, 03 of pearl millet, 04 of finger millet and one each of barley, sorghum, little millet and kodo millet were released for cultivation in different agro-ecologies of the country.

List of released varieties/hybrids of cereals

Variety	Area of adoption	Characters
Cereals		
Rice (*Oryza sativa*)		
RH 150025 (ADV 8082)	Chhattisgarh, Maharashtra	Rice hybrid suitable for *kharif* irrigated conditions, average grain yield 6.7–7.0 tonnes/ha, early duration (115–120 days) hybrid, moderately resistant to leaf blast, neck blast, false smut, stem-borer, caseworm.
JKRH 2354 (IET 26468)	Chhattisgarh, Madhya Pradesh, Maharashtra	Rice hybrid suitable for *kharif* irrigated condition, average grain yield 7.0–7.5 tonnes/ha, mid early duration (125–130 days), resistant to stem-borer; moderately resistant to to bacterial leaf blight (BLB), leaf blast, brown spot.
JKRH 2I54 (IET 24914)	Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal	Rice hybrid suitable for *kharif* irrigated condition, average grain yield 6.0–6.5 tonnes/ha, early duration (115–120 days), moderately resistant to BLB, leaf blast, brown spot.
CR Dhan 315 (IET27179)	Gujarat, Maharashtra	Suitable for *kharif*, average grain yield 5.0 tonnes/ha, medium duration (125–130 days), biofortified variety having high zinc content (25.47 ppm).
TRC 2015-5 (IET 26178) Aerobic Dhan-I	Karnataka, Chhattisgarh, Jharkhand	Suitable for aerobic conditions, short bold grain type, average grain yield 4.9 tonnes/ha, early duration (110–115 days), moderately resistant to leaf blast, neck blast and sheath blight.
TRC 2014-8 (IET 24197)	Karnataka, Himachal Pradesh	Suitable for low altitude hill ecology, average grain yield 4.2 tonnes/ha, medium duration (123–134 days), slender grain, moderately resistant to brown spot.
DRR Dhan 56 (IET 26803)	Punjab, Haryana	Suitable for irrigated early transplanted ecology, average grain yield 5.3 tonnes/ha, maturity 115 days, long slender grains, resistant to leaf blast, false smut, moderately resistant to BLB and tolerant to stem-borer.
Telangana Vari 3 (IET 26125-JGL 21078)	Telangana, Kerala	Suitable for irrigated mid early ecology, average grain yield 7.4 tonnes/ha, maturity 120 days, medium slender grain type, resistance to gall midge, moderately resistant to leaf blast.
DRR Dhan 53 (RP-6113-Patho-BB9 (IET 27294)	Andhra Pradesh, Telangana, Chhattisgarh, Maharashtra, Jharkhand, Odisha, Bihar, Gujarat, Maharashtra	Suitable for irrigated condition, average grain yield 5.5 tonnes/ha, maturity 130–135 days, MAS derived variety with additional '*Xa38*' gene, in the genetic background of Improved Samba Mahsuri (Xa21, xa13 and xa5), with enhanced resistance to bacterial blight.

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Variety	Area of adoption	Characters
DRR Dhan 55 (RP559)-123-16-2 (IET26194)	Bihar, Chhattisgarh	Suitable for aerobic ecology, average yield 5.0–5.5 tonnes/ha, early maturing (115–120 days), resistant to leaf blast, neck blast, gall midge and rice thrips and moderate resistance to plant hoppers.
DRR Dhan 54 (IET25653) (RP5943-421-16-1-1-B)	Bihar, Odisha, Telangana, Jharkhand, Haryana, Gujarat	Suitable for aerobic, average grain yield 5.3 tonnes/ha under water limited conditions, mid-early maturity (120–125 days), short-bold grain, tolerance to leaf blast, sheath rot and rice-tungro disease (RTD).
28544 (IET 26549) (PHI-17108)	Telangana, Karnataka, Andhra Pradesh	Hybrid rice suitable for *kharif*, average grain yield 6.5–7.0 tonnes/ha, medium maturity (135–140 days), medium-slender grain type, resistant to BLB, tolerant to leaf blast and leaf folder.
27P27 (IET 25745) (PHI-16101)	Uttarakhand, Chhattisgarh, Maharashtra	Rice hybrid suitable for *kharif*, average grain yield 7.0–7.5 tonnes/ha, mid-early maturity (125–130 days), moderate levels of resistance to leaf blast, neck blast, BLB and leaf folder.
Indam 100-012 (IET26999)	Uttar Pradesh, Punjab	Aromatic rice hybrid suitable for *kharif* irrigated condition, average grain yield 6.5–7.0 tonnes/ha, mid-early maturity (125–130 days), tolerant to stem-borer, resistant to false smut, moderately resistant to neck blast.
IET 26027 (wGL 697)	Telangana, Andhra Pradesh, Tamil Nadu, Kerala	Suitable for irrigated medium ecology, average grain yield 7.0 tonnes/ha, maturity 135 days, medium slender grains, multiple disease (blast, sheath rot and RTD) resistant and tolerant to plant-hopper and leaf-folder.
MTU Rice 1239 (IET 26263)	Andhra Pradesh, Tamil Nadu, Maharashtra	Suitable for late duration areas, average grain yield 6.3 tonnes/ha, maturity 150–155 days, medium-slender grain, moderately resistant to leaf blast and bacterial blight.
MTU 1223 (Varsha) (IET 25856)	Odisha, Bihar	Suitable for rainfed, shallow, lowland ecology, average grain yield 5.0 tonnes/ha, late maturing (150 days), non-lodging, low shattering, resistant to blast and BLB.
VL Dhan 88 (IET 25819) (VL 32224)	Himachal Pradesh, Meghalaya, Uttarakhand	Suitable for irrigated condition of hill ecology, average grain yield 5.0 tonnes/ha, early maturing (115–120 days), moderate resistance to leaf blast.
PNPH 24	Assam	Rice hybrid suitable for *kharif*, average grain yield 5.8–6.9 tonnes/ha, mid-early duration (125–130 days), tolerant to blast and brown spot, and drought.
Vikram-TCR (Vikram-Trombay Chhattisgarh Rice)	Chhattisgarh	Suitable for mid-early ecology, average grain yield 5.4 tonnes/ha, maturing 118–123 days, mutant line with short stature, resistant to lodging and tolerant to leaf blast and stem-borer.
CG Jawaphool Trombay (RTR-31)	Chhattisgarh	Improved over local Jawaphool for reduced plant height, average grain yield 4.0 tonnes/ha, medium maturity (130–135 days), short aromatic slender grain, tolerance to BLB, leaf-folder, and stem-borer.
NDR 9930111 (IET 19117)	Uttar Pradesh	Suitable for submerged condition, average grain yield 4.3 tonnes/ha, late maturing (140–145 days), withstand even under 12–17 days of flooding/ complete submergence and gives good yield.
Sabour Sampanna Dhan (IET 25960)	Bihar	Suitable for both drought and submergence condition, average grain yield 6.8 tonnes/ha (irrigated), 3.1 tonnes/ha (submergence) and 3.3 tonnes/ha (drought

(*Contd...*)

Variety	Area of adoption	Characters
		stress), late maturing (150 days), moderately resistant to BLB, leaf blast and brown spot diseases.
VL Sikkim Dhan-4 (VL 32130, IET 26596)	Sikkim	Suitable for irrigated, medium hill ecology, average yield 4.9 tonnes/ha, duration 135 days, moderately resistant to leaf blast, resistant to sheath rot, brown spot, sheath blight and false smut.
Swarna Samriddhi Dhan (IET 24306)	Bihar	Suitable for late duration areas, average grain yield 5.7 tonnes/ha, late maturing (135–140 days), resistant to false smut and moderately resistant to BLB, leaf blast, sheath blight, brown spot, RTD and glume discoloration.
NLR 40024	Andhra Pradesh	Suitable for early *kharif*, average grain yield 4.8 tonnes/ha, duration 122–125 days, tolerant to high temperature.
NLR 3041	Andhra Pradesh	Suitable for late duration, average grain yield 5.2 tonnes/ha, maturity 135–140 days, fine medium slender grain.
VL Dhan 159 (VL20083, IET 26598)	Uttarakhand Hills	Suitable for rainfed upland hill ecology, average grain yield 2.0 tonnes/ha, early maturing (110–115 days), resistant to stem-borer and leaf-folder.
GR 16 (Tapi) (NVSR 2233)	Gujarat	Suitable for rainfed upland ecology, average grain yield 3.6 tonnes/ha, early maturing (95–100 days), moderately resistant to leaf blast.
CG Barani Dhan-2 (R-RF-105, IET No.24690)	Chhattisgarh	Suitable for rainfed shallow lowland ecology, average grain yield 3.5 tonnes/ha, early maturing. (105–110 days)
Jammu Basmati 118 (IET 27733) (SJBR 118)	Jammu and Kashmir	Suitable for medium-duration cultivation, average grain yield 4.8 tonnes/ha, maturity 130–135 days, aromatic/scented rice, lodging resistant due to short stature.
Jammu Basmati 123 (IET 27718) (SJBR 123)	Jammu and Kashmir	Suitable for late duration cultivation, average grain yield 4.4 tonnes/ha, late maturity (150–155 days), aromatic/scented rice, moderately resistant to BLB, leaf blast and brown spot.
Jammu Basmati 138 (IET 27725) (SJBR 138)	Jammu and Kashmir	Suitable for late duration condition, average grain yield 4.5 tonnes/ha, late maturity (150–155 days), aromatic/scented rice, moderately resistant to bacterial leaf blight, leaf blast and brown spot.
Kau Pournami (MO 23) [(KAU M 109-1-2-1 (IET 23739)]	Kerala	Suitable for irrigated mid-early condition, average grain yield 7.4 tonnes/ha, maturity 115 to 120 days, red colour kernel, moderately resistant to sheath blight, sheath rot, gall midge and brown plant-hopper (BPH), high temperature, acidity and salinity-stress tolerant.
Kau-VTL-10 (Lavanya) KAU-VTL-51-5 (IET 25083)	Kerala	Suitable for irrigated, mid-early condition, average grain yield 4.2 tonnes/ha, maturity 110 to 115 days, red colour kernel, tolerant to acidity, salinity and submergence stress.
Kau Manu Rathna (HS-16)	Kerala	Suitable for lowland and kole cultivation as well as for irrigated early condition, average grain yield 4.5–5.7 tonnes/ha, short duration (95–99 days), tolerant to stem-borer, leaf-folder, whorl maggot and moderately tolerant to blast.

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Variety	Area of adoption	Characters
Kau Akshya [(PTB 62) (Kau PTB 0615-01-25-17) (Cul 06-14)]	Kerala	Suitable for irrigated condition, average grain yield 6.5 tonnes/ha, maturity 130 to 140 days, resistant to neck blast.
Kau VTL 11 (Jyotsna) (KAU. BIL4)	Kerala	Suitable for irrigated early condition, average grain yield 5.5 tonnes/ha, maturity 100–105, red colour kernel, tolerant to salinity stress.
Kau Supriya (PTB 61) KAU PTB 0614-7-8-24 (Cul 06-6)	Kerala	Suitable for irrigated condition, average grain yield 6.5 tonnes/ha, maturity 135–140 days, moderately resistant to neck blast and bacterial leaf blight.
Wheat (*Triticum aestivum*)		
HD 3293	Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Odisha, Assam, Plains of North Eastern states	Suitable for restricted irrigation, timely sown condition, average grain yield 3.93 tonnes/ha, maturity 129 days, highly resistant to wheat blast, tolerant to heat stress.
DDW 48 (Durum)	Maharashtra and Karnataka	Suitable for irrigated timely sown condition, average grain yield 4.74 tonnes/ha, maturity 111 days, bio-fortified variety with high grain protein (12.1%) and yellow pigment content (5.6 ppm), resistant to brown rust, high pasta acceptability.
Wheat 1270	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh, (except Jhansi division), Parts of Jammu & Kashmir (Jammu and Kathua Distt), Parts of Himachal Pradesh (Una Distt. and Paonta Valley), Uttarakhand Tarai region	Suitable for irrigated early sown, high fertility condition, average grain yield 7.58 tonnes/ha, maturity 156 days, resistant to yellow and brown rusts, good chapatti quality (7.66/10).
DBW 303 (Karan Vaishnavi)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (Except Jhansi division), Parts of Jammu and Kashmir (Jammu & Kathua Distt.), Parts of Himachal Pradesh (Una Distt. and Paonta Valley), Uttarakhand Tarai region)	Suitable for irrigated, early sown, high fertility condition, average grain yield 8.12 tonnes/ha, maturity 156 days, high grain protein content (12.1%), resistant to yellow and brown rust, good chapatti quality.
HD 3298	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division), Parts of Jammu and Kashmir (Jammu & Kathua Distt.), Parts of Himachal Pradesh (Una Distt. and Paonta Valley), Uttarakhand (Tarai region)	Suitable for irrigated very late sown condition, average grain yield 3.90 tonnes/ha, maturity 103 days, high grain protein (12.12%), iron (43.1 ppm), good chapatti quality and bread quality.
HI 1633 (Pusa Vani)	Maharashtra, Karnataka, Plains of Tamil Nadu	Suitable for irrigated late sown condition, average grain yield 4.17 tonnes/ha, maturity 100 days, bio-fortified wheat variety with high grain protein (12.4%), iron (41.66 ppm) and zinc (41.1 ppm), highly resistant to black rust.
HI 1634 (Pusa Ahilya)	Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan (Kota and Udaipur divisions), Western Uttar Pradesh (Jhansi division)	Suitable for irrigated late sown condition, average grain yield 5.16 tonnes/ha, maturity 108 days, highly resistant to brown and black rusts, good chapatti quality.
CG 1029 (Kanishika)	Madhya Pradesh, Gujarat, Chhattisgarh, Rajasthan (Kota and Udaipur divisions), Uttar Pradesh (Jhansi division)	Suitable for irrigated late sown condition, average grain yield 5.21 tonnes/ha, maturity 110 days, resistant to black and brown rusts, tolerant to heat stress, good chapatti quality.

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Variety	Area of adoption	Characters
NIDW 1149 (D)	Maharashtra, Karnataka	Suitable for restricted irrigation, timely sown, average grain yield 2.97 tonnes/ha, maturity 105 days, resistant to brown and yellow rusts.
GW 499	Gujarat	Suitable for irrigated late sown condition, average grain yield 4.60 tonnes/ha, maturity 95 days, resistant to brown and black rusts.
GW1339 (BANAS) (VD 2014-24)	Gujarat	Suitable for irrigated timely sown condition, average grain yield 4.96 tonnes/ha, maturity 102 days, resistant to brown and black rusts, good amount of yellow pigment (5.5 ppm).
VL 2015 (VL Gehun 2015)	Uttarakhand hills	Suitable for rainfed timely sown organic cultivation, average grain yield 1.99 tonnes/ha, maturity 168 days, resistant to yellow and brown rust, good sedimentation value.
MP 3465 (JW 3465)	Madhya Pradesh	Suitable for irrigated timely sown condition, average grain yield 5.94 tonnes/ha, maturity 117 days, high protein content (>14%), resistant to brown and black rusts.
Chhattisgarh Hanse Wheat (CG 1023)	Chhattisgarh	Suitable for restricted irrigation, timely sown condition, average grain yield 3.21 tonnes/ha, maturity 126 days, high zinc content (40.4 ppm), resistant to brown rust, good chapatti quality.
DBWH 221 (DBW 221)	Haryana	Suitable for timely sown irrigated conditions, average grain yield 6.28 tonnes/ha, maturity 135–149 days, highly tolerant to heat stress and resistant to yellow rust.
AAI-W 15 (SHUATS-W 15)	Uttar Pradesh	Suitable for timely sown rainfed conditions, average grain yield 1.99 tonnes/ha, maturity 105–110 days, tolerant to terminal heat tolerant at grain filling stage and resistant to brown and black rust.
UP 2944	Uttarakhand plains	Suitable for late-sown irrigated conditions, average grain yield 5.07 tonnes/ha, maturity 119–127 days, high protein content (14.5%), resistant to brown rust.
UP 2938	Uttarakhand plains	Suitable for timely sown irrigated conditions, average grain yield 5.38 tonnes/ha, maturity 136–139 days, resistant to brown rust.
UP 2903	Uttarakhand plains	Suitable for timely sown irrigated conditions, average grain yield 5.06 tonnes/ha, maturity 129–139 days, high protein content (12.68%) and resistant to brown rust.
Barley (*Hordeum vulgare*)		
DWRB 182 (Barley-1)	Punjab, Haryana, Delhi, Western Uttar Pradesh, Rajasthan (except Kota and Udaipur divisions)	Suitable for irrigated, timely sown condition, average grain yield 4.97 tonnes/ha, maturity 133 days, two-row malt barley, low beta glucan in grain (4.7%) and wort (506 ppm), higher malt diastatic power.
Maize (*Zea mays*)		
IQMH 202 (LQMH-2) (IIMRQPMH-1601)	Punjab, Haryana, Western Uttar Pradesh, Uttarakhand, Delhi	QPM hybrid suitable for irrigated conditions during *kharif*, average yield 7.20 tonnes/ha, medium maturing, rich in tryptophan (0.66%) and lysine (3.05%), moderately tolerant to MLB and *Chilo partellus*.

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Variety	Area of adoption	Characters
QMH 203 (LQMH-1705) (IIMRQPMH-1705)	Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh	QPM hybrid suitable for irrigated conditions during *kharif*, average grain yield 6.30 tonnes/ha, medium maturing, rich in tryptophan (0.77%) and lysine (3.48%), resistant to FSR, moderately tolerant to RDM, CLS and *Chilo partellus*.
HT 17169	Punjab, Haryana, Delhi, Uttar Pradesh	Suitable for both rainfed and irrigated conditions during *kharif*, average grain yield 9.64 tonnes/ha, maturity 120 days, highly responsive to high density and high fertilizer dose, resistant to maydis leaf blight (MLB) and charcoal rot (ChR), moderately resistant to *Chilo partellus*.
CP 858	Punjab, Haryana, Delhi, Uttarakhand (Plains), Uttar Pradesh (Eastern and Western regions), Bihar, Jharkhand, Odisha, West Bengal	Suitable for irrigated conditions during *Kharif*, average grain yield 8.82 tonnes/ha, late maturity (110–115 days), stay green trait, attractive grains colour, resistant to TLB and moderately resistant to ChR, MLB, banded leaf and sheath blight (BLSB), FSR, *S. inferens* and *Chilo partellus*.
NUZI 260 (Sweet Corn)	Punjab, Haryana, Delhi, Uttarakhand (Plains), Uttar Pradesh (Eastern and Western Regions), Bihar, Jharkhand, Odisha, West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Telangana	Suitable for irrigated conditions during *kharif*, average green ear yield (without husk) 11.2 tonnes/ha (NWPZ), 12.1 tonnes/ha (NEPZ) and 13.4 tonnes/ha (PZ), maturity 80–82 days, moderately resistant to MLB, ChR and P. Rust, and *Chilo partellus*, good sweetness of kernels with 15.4% TSS.
VL QPM Hybrid 59 (FQH 106)	Uttarakhand (Hills)	Suitable for rainfed condition of *kharif*, average grain yield 3.33 tonnes/ha under organic conditions, early maturity (90–95 days), high tryptophan (0.77%) and lysine content (3.33%), moderately resistant to TLB and MLB.
Pant Sankar Makka-5 (PSM-5)	Uttarakhand (Plains)	Suitable for both rainfed and irrigated conditions during *kharif*, average yield 4.97 tonnes/ha, maturity 87 days, stay green, suitable for industrial processing due to bold grain, moderately tolerant to MLB, TLB, FSR, SDM and BSR.
Jawahar Maize 215 (CHH 215)	Madhya Pradesh, Maharashtra, Chhattisgarh, Andhra Pradesh, Karnataka, Tamil Nadu	Suitable for rainfed ecology of *kharif*, average yield 4.13 tonnes/ha, early maturity (85 days), tolerant to stem-borer and MLB.
NMH 713	Assam	Suitable for irrigated conditions during *rabi*, average grain yield 9.49 tonnes/ha, maturity 155 days, resistant to common rust, moderately resistant to turcicum leaf blight (TLB), sorghum downey mildew (SDM) and *Sesamia inferens*.
NMH 731	Assam	Suitable for irrigated conditions during *rabi*, average grain yield 9.77 tonnes/ha, maturity 160 days, resistant to common rust, moderately resistant to TLB, post-flowering stalk rot (PFSR) and *Sesamia inferens*.
NMH 920	Assam	Suitable for *kharif* season under irrigated conditions, average grain yield 8.26 tonnes/ha, maturity 110 days, resistant to maydis leaf blight (MLB), moderately resistant to TLB, resistant to *Chilo partellus*.
PM 16202L (X35H270)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh	Suitable for *rabi* irrigated ecology, average grain yield 9.1 tonnes/ha, late maturing (109 days), responsive to higher plant densities and higher fertilizer level, moderately resistant to TLB, ChR and CR, *Chilo partellus*, *S. inferens* and shoot fly.

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Variety	Area of adoption	Characters
P3392 (PM 16205L)	Rajasthan, Gujarat, Madhya Pradesh	Suitable for *rabi* season irrigated ecology, average grain yield 9.2 tonnes/ha, late maturing (121 days), responsive to higher plant densities and higher fertilizer level, moderately resistant to FSR, ChR, TLB, *Chilo partellus* and *Sesamia inferens.*
P3302 (PM16103L)	Punjab, Haryana, Uttar Pradesh	Suitable for *rabi* irrigated ecology, average grain yield 8.5 tonnes/ha, medium-late (100–105 days) maturity, moderately resistant to MLB, TLB, BLSB, CR, RDM, CLS, *Chilo partellus*; responsive to higher plant densities and higher fertilizer level.
Rasi 3499 (RMH 3499)	Odisha, Jharkhand, Bihar, Uttar Pradesh (eastern part), West Bengal	Suitable for *Kharif* in medium to high fertility soils under irrigation or assured rainfall conditions, average grain yield 7.5 tonnes/ha, medium-late maturity (110–115 days), deep yellow grains, moderately resistant to MLB, TLB, BLSB and FSR, good stay green quality.
Pant Sankar Makka 6 (PSM 6) (DH 296)	Uttarakhand (Plains)	Suitable for both rainfed and irrigated ecology during the *kharif*, average grain yield 5.00 tonnes/ha, medium maturity (95 days), stiff stem, stay green and tight husk, moderately tolerant to MLB, TLB and *Polysora* rust.
PAC 745 Gold	Uttar Pradesh	Suitable for irrigated and rainfed conditions during *kharif*, average grain yield 6.7 tonnes/ha, medium maturity (95–100 days), long cobs with orange flint grains, excellent shelling (83%), resistant to TLB, DM and ESR.
BRMH 1	Karnataka	Average grain yield 7.0–7.2 tonnes/ha, late maturity (118–120 days), good shelling percentage (80–82%), yellow kernel, moderately resistant to TLB.
RCRMH 2	Karnataka	Average grain yield 6.2 tonnes/ha, medium duration, stay green, heat and drought tolerant, tolerant to Curvularia leaf spot (CLP), Rajasthan downy mildew (RDM), PFSR, TLB, Polysora rust, common rust (CR) and charcoal-rot (ChR) diseases.
Sorghum (*Sorghum bicolor*)		
CSH 42 (SPH 1883)	Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat	Sorghum hybrid suitable for rainfed ecology during *kharif*, average grain yield 4.0 tonnes/ha, early maturity (98–105 days), moderately resistant to grain moulds.
Pearl millet (*Pennisetum glaucum*)		
MP 7366 (MSH 346)	Rajasthan, Gujarat, Uttar Pradesh, Maharashtra, Tamil Nadu	Suitable for summer, average grain yield 5.1 tonnes/ha, maturity 89 days, highly resistant to downy mildew, smut and ergot diseases, tolerant to terminal stress condition, bio-fortified variety with high iron (69 ppm) and zinc (43 ppm).
VPMH 7	Karnataka	Suitable for *kharif*, average grain yield 2.4 tonnes/ha, maturity 85 days, moderately resistant to major diseases (downy mildew, smut and ergot), tolerant to lodging, bio-fortified variety with high iron (67 ppm) and zinc (52 ppm).
MBP 2 (Malnoor Bajra Population 2)	Karnataka	Suitable for *kharif* sowing, average grain yield 2.4 tonnes/ha, medium maturity, compact panicle, pale yellow, obovate seeds with high iron (72 ppm) and zinc (48 ppm) content, tolerant to major diseases and pests.

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Variety	Area of adoption	Characters
Little millet (*Panicum sumatrense*)		
CLMV 1 (Jaicar Sama 1)	Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu, Puducherry	Suitable for rainfed condition during *kharif*, average grain yield 1.58 tonnes/ha, dry fodder yield 4.4 tonnes/ha, medium maturity (98–102 days), rich in iron (59 ppm) and zinc (35 ppm), tolerant to shoot-fly, banded blight, leaf blight and brown spot diseases.
Finger Millet (*Eleusine coracana*)		
CFMV 2 (FMV 1118)	Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra, Odisha	Suitable for rainfed condition during *kharif*, average grain yield 2.95 tonnes/ha, dry fodder yield 8.6 tonnes/ha, medium maturity (119–121 days), rich in calcium (454 mg/100 g), iron (39 ppm) and zinc (25 ppm), resistant to leaf blast, foot rot, brown spot, grain mould.
CFMV 1 (Indravathi) (FMV 1116) (VR 1101)	Andhra Pradesh, Tamil Nadu, Karnataka, Puducherry, Odisha	Suitable for rainfed condition during *kharif*, average grain yield 3.11 tonnes/ha, dry fodder yield 8.4 tonnes/ha, medium maturity (110–115 days), high iron (58 ppm) and zinc (44 ppm) content, rich in calcium (428.3 mg/100 g) and anti-oxidant content (92 mg/100 g), resistant to finger blast, neck blast, banded blight, foot-rot, shoot aphid, stem-borer, grasshoppers.
VL Mandua 378	Uttarakhand	Suitable for rainfed organic ecology, average grain yield 2.1 tonnes/ha, medium maturity (114 days), high calcium (361 ppm) and iron (45 ppm), moderately resistant to neck and finger blast.
VL Mandua 382	Uttarakhand	Suitable for rainfed organic ecology, average grain yield 2.28 tonnes/ha, medium maturity (112 days), white coloured grains, higher calcium (340 ppm) and protein content (8.8%), very low tannin content, suitable for processing industry.
Kodo millet (*Paspalum scrobiculatum*)		
Gujarat Anand Kodra 3 (GAK 3)	Gujarat	Suitable for rainfed organic ecology of hilly and tribal region of Dahod and Panchmahal districts of middle Gujarat, average grain yield 2.46 tonnes/ha, medium maturity (114 days), good nutritional properties, high protein content and minerals, milling recovery 53.4%, highly resistant to shoot fly, moderately resistant to head smut.

Oilseeds

Forty six high yielding oilseed varieties comprising 25 of soybean, 7 of rapeseed mustard, 4 of groundnut, 6 of linseed, 2 of sesame and one each of safflower and castor 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 Mustard 32 (LES 54)	Rajasthan (Northern and Western Parts), Punjab, Haryana, Delhi, Western Uttar Pradesh, Plains of Jammu & Kashmir, Himachal Pradesh	Low erucic acid (<2%) mustard variety, suitable for timely-sown irrigated condition, average seed yield 2.71 tonnes/ha, oil content 38%, maturity 145 days.
Radhika (DRMR 2017-15)	Jammu, Punjab, Haryana, Delhi, Rajasthan	Suitable for irrigated late sown conditions (November) under irrigated condition, average seed yield 1.79

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Variety	Area of adoption	Characters
		tonnes/ha, oil content 40.7%, maturity 131 days, tolerant to high temperature at terminal stage.
Brijraj (DRMRIC 16-38)	Jammu, Punjab, Haryana, Delhi, northern Rajasthan	Suitable for late sown (November) under irrigated condition, average seed yield 1.73 tonnes/ha, oil content 39.9%, maturity 132 days, tolerant to high temperature at terminal stage.
SVJH 108	Haryana	Suitable for irrigated conditions under high and low fertility, average grain yield 2.4 tonnes/ha, oil content 41.3%, black and bold seed (6.1 g/1000-seed).
Azad Mahak [(KMR (E) 15-2)]	Uttar Pradesh	Suitable for timely sown irrigated conditions, average seed yield 2.05 tonnes/ha, oil content 41.6%, maturity 120–125 days, tolerant to high temperature.
Toria (*Brassica rapa*)		
Azad Chetna (TKM 14-2)	Uttar Pradesh	Suitable for early sowing (Mid-September) under irrigated conditions, average seed yield 1.44 tonnes/ha, oil content 42.2%, escapes infestation/ exposure to *Alternaria* blight, aphid and fog due to early maturity.
Raj Vijay Toria 2 (RMT 08-2)	Madhya Pradesh	Suitable for double cropping system under irrigated and rainfed conditions, average seed yield in irrigated condition 1.04–1.2 tonnes/ha (irrigated), 0.94 tonnes/ ha (rainfed), oil content 41.9%, early maturing (108 days).
Groundnut (*Arachis hypogaea*)		
K1719 (Kadiri Chithravathi)	Andhra Pradesh, Telangana, Tamil Nadu	Suitable for *rabi*-summer condition under both high and low fertility conditions, average pod yield 2.17 tonnes/ha, maturity 110–113 days, tolerance to collar rot, peanut bud necrosis disease (PBND) and moderately resistant to thrips.
DH 257	Karnataka, Maharashtra	Suitable for *rabi*-summer condition, average pod yield 3.28 q/ha, maturity 120–125 days.
K 1812 (Kadiri Lepakshi)	Andhra Pradesh, Telangana, Tamil Nadu, Karnataka	Suitable for rainfed conditions, average pod yield 3.89 tonnes/ha, maturity 107–113 days, resistant to collar rot, stem rot, dry root rot, ELS, LLS, *Alternaria* leaf blight, *Spodoptera*, leaf miner and thrips.
J 87 (GG 36)	Punjab, Uttar Pradesh	Suitable for *rabi*-summer condition, average pod yield 4.17 tonnes/ha, maturity 107–109 days, large seeded with 100-kernel weight of 63 g.
Soybean (*Glycine max*)		
MACS 1407	Jharkhand, Chhattisgarh, Assam, West Bengal	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 2.1 tonnes/ha, 41% protein and 19.8% oil content, maturity 104 days, resistant to girdle beetle, leaf-miner, leaf-roller under field conditions.
MACS 1460	West Bengal, Jharkhand, Chhattisgarh, Odisha, Assam, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana	Suitable for irrigated and rainfed conditions during *kharif*, average grain yield 2.04 tonnes/ha (NEHZ), Eastern Zone 2.09 tonnes/ha (EZ) and 2.25 tonnes/ ha (SZ); 17.6 to 18.9% oil content, 41% protein; maturity 97 days (EZ),101 days (NEHZ), 89 days (SZ); suitable for mechanical harvesting.
MACS 1520	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat, Marathwada and Vidarbha region of Maharashtra	Suitable for irrigated and rainfed conditions during *kharif*, average grain yield 2.21 tonnes/ha, oil content 19%, maturity 98–102 days, resistant to charcoal-rot.

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Variety	Area of adoption	Characters
NRC 132	West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha, Southern Maharashtra, Karnataka, Telengana, Andhra Pradesh, Tamil Nadu	Suitable for irrigated and rainfed conditions during *kharif*, First variety of India with less beany flavour (null lipoxygenase 2), developed through marker-assisted selection, average seed yield 2.29 tonnes/ha (SZ), 1.65 tonnes/ha (EZ); 18–19% oil content, maturity 98 days (SZ), EZ 104 days (EZ).
NRC 147	West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha, Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu	Suitable for irrigated and rainfed conditions during *kharif*, first variety with 42±5% oleic acid content; average seed yield 2.36 tonnes/ha (SZ) 1.40 tonnes/ha (EZ), oil content 17% (EZ), 19% (SZ); maturity 96 days (SZ), 100 days (EZ).
NRC 128	Punjab, Uttar Pradesh (except Bundelkhand region of Uttar Pradesh), Delhi), West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 1.87 tonnes/ha (EZ), 2.27 tonnes/ha (NPZ); oil content 18–19%, maturity 106 days (EZ), 118 days (NPZ); resistant to pod blight and Indian bud blight, moderate antixenosis against *Spodoptera litura*.
NRC 130	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat, Marathwada and Vidarbha region of Maharashtra	Suitable for irrigated and rainfed conditions during *kharif*, variety with photo- insensitive allele e3; average seed yield 1.52 tonnes/ha, 17.8% oil content, early maturity (92 days), moderate antixenosis against *Spodoptera litura*, unique brown spot on micropile.
NRC 136	West Bengal, Bihar, Jharkhand, Chhattisgarh, and Odisha	Suitable for irrigated and rainfed conditions during *kharif*, first variety developed for drought tolerance, average seed yield 1.70 tonnes/ha, oil content 17.5%, maturity 107 days, highly resistant to Indian bud blight, moderate antixenosis against *Spodoptera litura*.
NRCSL1	West Bengal, Bihar, Jharkhand. Chhattisgarh, Odisha	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 1.82 tonnes/ha,19.5% oil content, maturity 107 days, tolerant to YMV disease, highly resistant to Indian bud blight.
RSC 11-07	Eastern Zone (West Bengal. Bihar, Jharkhand, Chhattisgarh and Odisha) Southern Zone (Southern Maharashtra, Karnataka,Telangana, Andhra Pradesh and Tamil Nadu excluding rust prone areas on banks of river Krishna)	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 1.92 tonnes/ha (EZ), SZ 2.52 tonnes/ha (SZ); 18–19% oil content, maturity 102 days (EZ), 97 days (SZ), resistant to Indian bud blight and pod blight (ct).
RSC 10-46	Eastern Zone (West Bengal, Bihar, Jharkhand, Chhattisgarh and Odisha, Central Zone (Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Marathwada and Vidarbha region of Maharashtra)	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 2.04 tonnes/ha (CZ), 1.95 tonnes/ha (EZ), Oil content 19.8% (CZ), 17.8% (EZ); maturity 102 days (CZ), 104 days (EZ); resistant to charcoal rot and Indian bud blight.
RSC l0-52	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Marathwada and Vidarbha region of Maharashtra	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 2.05 tonnes/ha, oil content 18%, maturity 101 days, resistant to charcoal-rot, bacterial pustule, TLS, MLS, IBB, RAB.
AMS 2014-l (PDKV Purva)	West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 1.8 tonnes/ha, 18.5% oil content, maturity 106 days, resistant to charcoal rot, RAB, BLB, ALS.

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Variety	Area of adoption	Characters
AMS-MB-5-I8 (Suvarn Soya)	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat, Maharashtra	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 2.04 tonnes/ha, oil content 19%, maturity 100 days.
DSB 34	Karnataka, Telangana, Andhra Pradesh, Tamil Nadu and Southern partsof Maharashtra	Suitable for irrigated and rainfed conditions during *kharif*, average seed yield 2.66 tonnes/ha oil content 18.6%, maturity 95 days, highly resistant to rust and purple seed stain, moderately resistant to pod blight.
RVSM 2011-35 (RVSM 35)	Madhya Pradesh, Bundelkhand Region of Uttar Pradesh, Marathwada and Vidarbh Region of Maharashtra, Rajasthan and Gujarat	Suitable for irrigated and rainfed conditions, average seed yield 2.2 q/ha, maturity 98 days, moderately resistant to PB(ct), YMV and TLS, multiple resistant for stem-fly, girdle beetle and defoliators.
NRC 138	Madhya Pradesh, Bundelkhand Region of Uttar Pradesh, Rajasthan, Gujarat, Marathwada and Vidarbh Region of Maharashtra	Suitable for irrigated and rainfed conditions, average seed yield 1.79 tonnes/ha, maturity 93 days, moderately resistant to PB(ct), TLS, resistant to YMV.
AMS 100-39 (PDKV Amba)	Madhya Pradesh, Bundelkhand Region of Uttar Pradesh, Rajasthan, Gujarat, Marathwada and Vidarbh Region of Maharashtra	Suitable for irrigated and rainfed conditions, average seed yield 2.09 tonnes/ha, maturity 97 days, moderately resistant to charcoal-rot and MLS; antibiosis reaction for defoliators, resistant to defoliators, stem-fly and R-HY/S-HY reaction to pest complex.
MACSNRC 1667	Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu (excluding rust prone areas on bank of river Krishna like Southern Maharashtra, entire area of Belagavi, Dharwad, Haveri Bidar and Bagalkot district)	Suitable for irrigated and rainfed conditions, average seed yield 2.05 tonnes/ha, maturity 96 days, MAS derived EDV of MACS 450 for null KTI.
KBVS 1 (Karune)	Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, Southern part of Maharashtra	Vegetable soybean variety, suitable for irrigated and rainfed conditions, average green pod yield 10.64 tonnes/ha, 68 days to pod harvest, moderately resistant to PB.
Raj Vijay Soybean [RVS 76]	Madhya Pradesh, Bundelkhand Region of Uttar Pradesh, Marathwada and Vidarbh Region of Maharashtra, Rajasthan, Gujarat	Suitable for irrigated and rainfed conations, average yield 2.07 tonnes/ha, maturity 101 days, resistant to charcoal rot.
NRC 142	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat and Marathwada and Vidarbh region of Maharashtra, Southern Maharashtra, Karnataka, Telangana, Andhra Pradesh and Tamil Nadu (excluding rust prone areas on bank of river Krishna like Southern Maharashtra, entire area of Belagavi, Dharwad, Haveri Bidar and Bagalkot district)	Suitable for irrigated and rainfed conations, average seed yield 2 tonnes/ha (CZ) and 2.21 tonnes/ha (SZ), maturity 97–99 days, India's FIRST double null for KTI and Lox 2 developed through MAS, resistant to YMV.
SL 1074	Punjab, Haryana, Uttar Pradesh (except Bundelkhand region of Uttar Pradesh), Delhi	Suitable for irrigated and rainfed conditions, average seed yield 1.92 tonnes/ha, 19.5% oil content and 39.5% protein in seeds, maturity 122 days, tolerant to YMV.
SL 1028	Punjab, Haryana, Uttar Pradesh (except Bundelkhand region of Uttar Pradesh), Delhi	Suitable for irrigated and rainfed conditions, average yield 2.2 tonnes/ha, 19.8% oil content and 39.2% protein, maturity 124 days, moderately resistant to YMV.

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Variety	Area of adoption	Characters
Pusa Soybean 06	National Capital Region of Delhi	Suitable for irrigated timely-sown and high- fertility condition, average seed yield 2.1 tonnes/ha, high oil content (20.7%) and protein (32.14%) content, maturity 124 days, resistant to YMV, RAB, BP, moderately resistant to stem-fly, defoliators.
Linseed (*Linum usitatissimum*)		
LMS 2015-31	Rajasthan, Madhya Pradesh, Maharashtra, Odisha, Chhattisgarh, Karnataka.	Suitable for irrigated condition, average seed yield 1.26 tonnes/ha, oil content 32%, maturity 120–122 days, moderately resistant to bud fly, powdery mildew and *Alternaria* leaf blight.
LCK 1611 (Aparna)	Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana	Suitable for irrigated condition, average seed yield 1.34 tonnes/ha, oil content 37%, maturity 168 days, moderately resistant to rust and bud fly.
RLC 164	Jammu & Kashmir, Himachal Pradesh, Punjab, Chhattisgarh	Suitable for rainfed condition, average seed yield 1.16 tonnes/ha, oil content 32.6%, maturity 161 days, resistant to rust, moderately resistant to *Alternaria* blight and bud fly.
RLC 167	Jammu & Kashmir, Himachal Pradesh, Punjab, Chhattisgarh	Suitable for irrigated condition, average seed yield 1.30 tonnes/ha, oil content 34.3%, maturity 160 days (Jammu, Himachal Pradesh, Punjab), 120 days (Chhattisgarh); resistant to rust, moderately resistant to bud fly and *Alternaria* leaf blight.
Kota Alsi 6 (RL 13165)	Uttar Pradesh, Jharkhand, Bihar, West Bengal, Assam	Suitable for irrigated conditions, average seed yield 1.18 tonnes/ha, oil content 35%, maturity 130–135 days, moderately resistant to wilt, powdery mildew, rust and *Alternaria* blight.
RL 15584	Himachal Pradesh, Jammu, Punjab	Suitable for rainfed conditions, average seed yield 0.92 tonnes/ha, oil content 32%, maturity 150–155 days, moderately resistant to wilt, powdery mildew, *Alternaria* blight and bud fly.
Safflower (*Carthamus tinctorius*)		
IGKV Kusum (RSS 2016-03)	Chhattisgarh, Madhya Pradesh	Suitable for late-sown irrigated conditions, average seed yield 2.71 tonnes/ha, oil content 34.26%, maturity 138–140 days.
Castor (*Ricinus communis*)		
Jawahar Castor 26 (JC 26)	Madhya Pradesh	Suitable for both rainfed and irrigated conditions, average seed yield 1.88 tonnes/ha, oil content 46–49%, medium maturity (100–130 days), moderately resistant to *Fusarium* wilt and root-rot.
Sesame (*Sesamum indicum*)		
RT 372	Rajasthan, Haryana, Punjab, Gujarat, Himachal Pradesh, Uttar Pradesh, Maharashtra, Nagaland	Suitable for rainfed condition, white seeded with average seed yeild 0.65–0.7 tonnes/ha, maturity 85–87 days, moderately resistant to Macrophomina stem and root-rot, phyllody, *Alternaria* leaf spot, bacterial leaf spot and powdery mildew.
SVT 222	Haryana	Suitable for high and low fertility rainfed areas, shinning white seed colour with average seed yield 0.6–0.7 tonne/ha, oil content 46–47%, maturing 84–90 days, suitable to early and timely sown conditions, moderately resistant to *Macrophomina* stem and root-rot, phyllody and powdery mildew.

Pulses

Thirty two high yielding varieties of pulses comprising 13 of chickpea, 8 of pigeonpea, 4 of lentil, 3 of fieldpea, 2 fababean and one each of mungbean and clusterbean were released for different agro-ecological regions.

List of released varieties/hybrids of Pulses

Variety	Area of adoption	Characters
Chickpea (*Cicer arietinum*)		
Jawahar Gram Kabuli 6 (JGK 6) (JGK 2017-32)	Punjab, Haryana, Uttar Pradesh, Rajasthan, Jammu and Kashmir	Large seeded (40.3 g/100 seeds) kabuli chickpea variety suitable for timely-sown irrigated condition, average seed yield 1.70 tonnes/ha, maturity 143 days.
Raj Vijay Gram 204 (RVG 204)	Madhya Pradesh, Maharashtra, Chhattisgarh, Parts of Rajasthan, Gujarat	Suitable for timely-sown irrigated condition, average seed yield 2.25 tonnes/ha, maturity 110 days, 100-seed weight 23.8 g, amenable to mechanical harvesting.
Raj Vijay Kabuli Gram 2020 (RVKG 2020) (RVSSG 63)	Punjab, Haryana, Uttarakhand, Rajasthan	Kabuli variety suitable for timely-sown irrigated condition, average seed yield 1.66 tonnes/ha, maturity 143 days, 100-seed weight 38.83 g.
RG 2015-08 (CG Lochan Chana)	Chhattisgarh, Madhya Pradesh	Suitable for cultivation under timely-sown irrigated condition, average seed yield 2.23 tonnes/ha, maturity 106 days, 100-seed weight 25.46 g.
PBG 9 (GL 13001)	Uttar Pradesh, Bihar, Jharkhand, Assam, West Bengal	Suitable for cultivation under timely sown irrigated condition, average seed yield 1.75 tonnes/ha, maturity 132 days, 100 seed weight 25 g, moderately resistant to wilt.
Kota Kabuli Channa 2 (RKGK 13-499)	Rajasthan, Delhi, Uttarakhand, Haryana, Punjab, Jammu and Kashmir	Large seeded (40.7 g/100 seed) kabuli chickpea variety suitable for timely-sown irrigated condition, average seed yield 1.73 tonnes/ha, maturity 143 days.
PDKV-Kanak (AKG-1303)	Maharashtra, Gujarat, Madhya Pradesh	Suitable for cultivation under timely-sown irrigated condition, average seed yield 2.48 tonnes/ha, maturity 132 days, 100-seed weight 21.74 g, moderately resistant to wilt.
Pusa Chickpea 20211 (Pusa Chickpea Manav)	Madhya Pradesh, Maharashtra, Gujarat	Suitable for timely-sown irrigated condition, average seed yield 2.29 tonnes/ha, maturity 108 days, 100-seed weight 19.5 g, Fusarium wilt resistant introgression line (MAS) of desi chickpea variety Pusa 391 developed through introgression of "QTL region" for wilt resistance on LG 2 having QTLs 1, 3, 4 and 5 from WR 315.
Raj Vijay Gram 210 (RVG 210)	Madhya Pradesh	Suitable for semi-irrigated/irrigated condition, average yield 1.81 tonnes/ha, maturity 105 days, 100-seed weight 26.7 g, resistant against *Fusarium* wilt.
Raj Vijay Kabuli Gram 121 (RVKG 121)	Madhya Pradesh	Kabuli variety suitable for semi-irrigated/irrigated areas, average seed yield 1.97 tonnes/ha, maturity 114 days,100-seed weight 27.8 g, resistant against *Fusarium* wilt.

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Variety	Area of adoption	Characters
Nandyal Gram 810 (NBeG 810)	Punjab, Haryana, Western Uttar Pradesh, Delhi, North Rajasthan, Jammu and Kashmir, Uttarakhand, Gujarat, Maharashtra, Western Madhya Pradesh, Bundelkhand region of Uttar Pradesh	Suitable for irrigated timely sown condition, average seed yield 1.53 tonnes/ha, maturity 110–115 days (WCZ) and 145–150 days (NWPZ), 100 seed weight 41 g, moderately resistant to wilt.
RLB Chana Kabuli 1 (RLBGK 1)	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, parts of Odisha	Suitable for irrigated timely-sown condition, average seed yield 1.5 tonnes/ha, maturity 94–104 days, 100-seed weight 36 g, moderately resistant to wilt.
Pant Gram 7 (PG 172)	Uttarakhand plains	Suitable for rainfed/irrigated timely-sown condition, average seed yield 1.65 tonnes/ha, maturity 145 days, 100-seed weight 20.6 g, moderately resistant to wilt.
Pigeonpea (*Cajanus cajan*)		
LRG 133-33	Tamil Nadu, Karnataka, Andhra Pradesh and Telangana	Suitable for rainfed and irrigated condition in *kharif*, average seed yield: 1.54 tonnes/ha, maturity 164–174 days, resistant to fusarium wilt and sterility-mosaic disease, tolerant to pod-fly and pod-borer.
Hybrid: IPH 09-5	Punjab, Haryana, Western Uttar Pradesh, Rajasthan, Delhi	Suitable for rainfed condition in *kharif*, average seed yield 1.82 tonnes/ha, maturity 150 days, resistant to fusarium wilt and tolerant to sterility mosaic disease, *Phytophthora* stem blight, pod-fly and pod-borer complex.
IPA 15-2	Eastern Uttar Pradesh, Bihar, Odisha, Jharkhand, West Bengal, parts of Assam	Suitable for rainfed condition in *kharif*, average seed yield 2.27 tonnes/ha, maturity 240–255 days, resistant to fusarium wilt and sterility mosaic disease and tolerant to pod-borer.
WRGE 121	Karnataka, Telangana, Andhra Pradesh, Odisha, Tamil Nadu	Suitable for rainfed condition in *kharif*, average seed yield 1.7 tonnes/ha, maturity 155–165 days, resistant to fusarium wilt and sterility mosaic disease and tolerant to pod-borer complex, resistant to *H. cajani* nematode
KRG 33	Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Chhattisgarh	Suitable for irrigated/rainfed condition in *kharif*, average seed yield 2.0–2.1 tonnes/ha, matures in 165 days, resistant to wilt and sterility mosaic disease and tolerant to pod-fly and pod- borer.
Pant Arhar 7 (PA 477)	Uttarakhand plains	Suitable for timely-sown, irrigated/rainfed condition, average seed yield 1.3–1.5 tonnes/ha, matures in about 145 days, resistant to sterility mosaic disease.
Pusa Arhar 2017-1	National Capital Region of Delhi	Suitable for irrigated/rainfed condition, average seed yield 1.3–1.5 tonnes/ha, matures in 125 days, moderately resistant to wilt.
Pusa Arhar 2018-2	National Capital Region of Delhi	Suitable for irrigated/rainfed condition, average seed yield 1.6–1.7 tonnes/ha, matures in about 128 days, moderately resistant to wilt.
Mung bean (*Vigna radiata*)		
Pusa 1641	National Capital Region of Delhi	Suitable for summer, average seed yield 1.3 tonnes/ha, maturity 62–64 days, resistant to MYMV and low incidence of major insect pests.
Lentil (*Lens culinaris*)		
RKL 58 F 3715 (Kota Masoor 4)	Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh (Bundelkhand region), South-East Parts of Rajasthan	Suitable for normal sowing conditions (10 November), average seed yield 1.87 tonnes/ha, maturity 112 days, resistant to rust and *Stemphylium* blight, moderately resistant to wilt.

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Variety	Area of adoption	Characters
IPL 329	Uttar Pradesh	Suitable for timely-sown rainfed condition, average seed yield 1.01 tonnes/ha, maturity period 115–134 days. resistance to rust and Fusarium wilt diseases, a large seeded (2.9 g/100 seeds) variety with brown dotted seed coat and red cotyledons.
IPL 225	Uttar Pradesh	Suitable for timely-sown condition, average seed yield 1.03 tonnes/ha, maturity 115–120 days, highly resistance to rust and *Fusarium* wilt diseases, a small seeded (2.1 g/100 seeds) variety with brown dotted seed coat and red cotyledons.
Pant Lentil 11(PL 164)	Uttarakhand	Suitable for timely-sown rainfed/irrigated condition, average seed yield 1.2 kg/ha, maturity 101–132 days, resistant to rust disease and moderately resistant to pod- borer.
Field pea (*Pisum sativum*)		
HFP 1428	Punjab, Haryana, Delhi, Rajasthan, Uttarakhand, parts of Jammu and Kashmir and Western Uttar Pradesh	Suitable for *rabi*, average seed yield 2.6 tonnes/ha, maturity 123 days, resistant to powdery mildew, *Ascochyta* blight and root-rot and moderately resistant to rust and less incidence of pod-borer and aphids.
Pant Pea 347 (Pant P 347)	Punjab, Haryana, Delhi, North West and Central Rajasthan, Western Uttar Pradesh and plains of Uttarakhand and Jammu and Kashmir	Suitable for rainfed/ irrigated condition, average seed yield 2.54 tonnes/ha, maturity 124 days, resistant to powdery mildew and Ascochyta blight and moderately resistant to rust and root-rot diseases.
Pant Pea 195 (Pant P 195)	Uttarakhand plains	Suitable for timely-sown rainfed/irrigated condition, average seed yield 1.48 tonnes/ ha, maturity 114–136 days, resistant to powdery mildew and rust diseases and moderately resistant to pod-borer.
Faba bean (*Vicia faba*)		
Swarna Gaurav	Bihar	Suitable for irrigated condition, average productivity 3.5–4 tonnes/ha under sole cropping and 2–2.2 tonnes/ha under intercropping system, early maturing (120–125 days), nutritionally superior (Phytate <0.10% and iron >200 ppm), moderately resistant to major insect pests and diseases, bushy type plant (77–105 cm), short bold grains (281 g/1000-seed), pod length 4.0–4.5 cm and sweetness of the mature seeds is 10.34 TSS.
Swarna Suraksha	Bihar	A drought tolerant variety suitable for rainfed condition, average seed yield 2.5–3.1 tonnes/ ha, early maturing (110–115 days), moderately resistant to major insect pest and diseases, nutritionally superior (Phytate<0.10% and iron >200 ppm), semi bushy type plants (70–90 cm), short bold grains (270 g/1000-seed), pod length 4–4.5 cm, and sweetness of the mature seeds is 10.9 TSS
Clusterbean (*Cyamopsis tetragonoloba*)		
X 10	Haryana	Suitable for rainfed under both high and low fertility condition, average seed yield 1.8–2.0 tonnes/ha, maturity 90–95 days, resistant to root-rot and bacterial blight.

Commercial crops

Seventy one high yielding varieties/hybrids of commercial crops including 62 of cotton, 6 of sugarcane, 2 of jute and 1 of Mesta were released for different agroecological regions.

List of improved released varieties/hybrids of Commercial crops

Variety	Area of adoption	Characters
Cotton (*Gossypium* spp.)		
LAHB Cotton 1	Karnataka, Tamil Nadu, Andhra Pradesh	Extra Long Staple (ELS) HxB hybrid suitable for irrigated conditions during *kharif*, average seed cotton yield 1.79 tonnes/ha, maturity 180–195 days, tolerant to drought, *Alternaria* leaf spot (ALS), bacterial leaf blight (BLB), grey-mildew (GM).
LHDP Cotton 1	Karnataka, Tamil Nadu, Andhra Pradesh	Compact variety for irrigated ecosystem under high-density planting system during *kharif*, seed cotton yield 2.41 tonnes/ha, maturity: 145–155 days, resistant to BLB and grey-mildew and moderately resistant to rust.
CICR-H Cotton 36 (Suraksha)	Gujarat, Maharashtra, Madhya Pradesh, Odisha, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu	ELS cotton variety suitable for irrigated conditions during *kharif*, seed cotton yield 1.6 tonnes/ha, maturity 150–160 days, resistant to BLB, GM, root-rot, tobacco streak virus; tolerant to ALS and rust; and immune to root-rot; tolerant/resistant to jassids, white-fly, thrips, aphids, miridbug.
BS 279 (Culture Name BS 279)	Odisha	Suitable for irrigated upland ecosystem during *kharif*, seed cotton yield 2.56 tonnes/ha, maturity 150–160 days, moderately resistant to BLB, ALS and GM.
BS 30 (Irrigated/ Rainfed conditions)	Maharashtra, Gujarat, South Rajasthan, Madhya Pradesh, Odisha	Suitable for irrigated/ rainfed ecosystem, seed cotton yield 1.89 tonnes/ha, maturity 150–160 days, moderately resistant to bacterial leaf blight and grey-mildew and to sucking pests.
Phule Mahi (RHB 1122) (SZ) (CZ)	Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Madhya Pradesh and Gujarat	ELS H×B hybrid suitable for irrigated ecosystem, high fertilizer responsive and timely sown conditions, seed-cotton yield 2.03 tonnes/ha, maturity 170–180 days.
CICR-B Cotton 37 (CCB 51)	Irrigated conditions of Andhra Pradesh, Telangana, Karnataka and Tamil Nadu	ELS *G. barbadense* variety suitable for irrigated ecosystem, seed cotton yield 1.24 tonnes/ha, maturity 165–170 days.
KR 111	Haryana	Suitable for irrigated conditions under high and low fertility, seed-cotton yield 2.47 tonnes/ha, maturity 160–165 days, non-spinnable desi cotton hybrid.
***Bt*-cotton/ Hybrids**		
NBHB 1851 (H×B) BG II	Karnataka, Tamil Nadu	ELS H×B Hybrid suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.78 tonnes/ha, maturity 170–180 days.
NBC 1821 BG II	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.80 tonnes/ha, maturity 150–160 days.
NBC 1111 BG II	Maharashtra, Madhya Pradesh, Gujarat	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.30 tonnes/ha, maturity 160–165 days.
JKCH 15551 BGII	Maharashtra, Madhya Pradesh, Gujarat	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 2.11 tonnes/ha, maturity 160–170 days.
NEO 1635 BG II	Maharashtra, Madhya Pradesh, Gujarat	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.11 tonnes/ha, maturity 130–140 days.

(*Contd...*)

Variety	Area of adoption	Characters
NEO 1655 BG II	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.11 tonnes/ha, maturity 135–140 days.
PRCH 2799 Bt2	Gujarat, Maharashtra, Madhya Pradesh	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.21 tonnes/ha, maturity 140–150 days.
YCH 7475 Bt2	Maharashtra, Madhya Pradesh, Gujarat	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.17 tonnes/ha, maturity 140–150 days.
ARCH 888 BGII	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 2.51 tonnes/ha, mid-late maturity.
KCH 305 BG II_CZ	Gujarat, Maharashtra, Madhya Pradesh	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 1.94 tonnes/ha, maturity 160–165 days.
KCH 307 BG II	Haryana, Punjab, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.73 tonnes/ha, maturity 165–170 days.
ARCH 045 BG II	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.50 tonnes/ha, mid-late maturity.
ARCH 501 BG II	Madhya Pradesh, Maharashtra, Gujarat	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.93 tonnes/ha, mid-late maturity.
ARCH 777 BG II	Madhya Pradesh, Maharashtra, Gujarat	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.01 tonnes/ha, mid-late maturity.
SAMIR BGII	Madhya Pradesh, Maharashtra, Gujarat	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.06 tonnes/ha, mid-late maturity.
SP 7670 BG II	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.05 tonnes/ha, maturity 160–170 days.
ACH-171-2 BG II	Maharashtra, Madhya Pradesh	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 2.06 tonnes/ha, mid-late maturity.
ACH-900-2 BG II_CZ	Maharashtra, Madhya Pradesh	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.06 tonnes/ha, maturity 145–155 days.
ACH-945-2 BG II	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 4.14 tonnes/ha, maturity 145–155 days.
ACH-955-2 BG II	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.63 tonnes/ha, maturity 150–160 days.
ACH-1155-2 BG II	Telangana, Andhra Pradesh, Karnataka and Tamil Nadu	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.06 tonnes/ha, maturity 150–160 days.
RCH 938 BG II	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.86 tonnes/ha, maturity 160–170 days.

(*Contd...*)

Variety	Area of adoption	Characters
RCH 951 BG II	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.6 tonnes/ha, maturity 160–170 days.
RCH 947 BG II_CZ	Maharashtra, Madhya Pradesh, Gujarat, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.93 tonnes/ha, maturity 160–170 days.
RCH 956 BG II	Maharashtra, Madhya Pradesh, Gujarat	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.87 tonnes/ha, maturity 160–170 days.
RCH 953 BG II	Maharashtra, Madhya Pradesh, Gujarat	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.7 tonnes/ha, maturity 160–170 days.
RCH 933 BG II	Maharashtra, Madhya Pradesh, Gujarat	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.83 tonnes/ha, maturity 160–170 days.
RCH 846 BG II	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 3.69 tonnes/ha, maturity 160–170 days.
RCH 926 BG II	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.53 tonnes/ha, maturity 160–170 days.
RCH 929 BG II_CZ	Maharashtra, Madhya Pradesh, Gujarat, Rajasthan	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.65 tonnes/ha, maturity 160–170 days.
MC 5403 BGII	Punjab	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 3.6 tonnes/ha, maturity 150–155 days.
MC 5405 BGII	Andhra Pradesh, Telangana, Karnataka	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.02 tonnes/ha, maturity 150–160 days.
MC 5408 BGII	Punjab, Haryana, Rajasthan	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.8 tonnes/ha, maturity 150–155 days.
MC 5431 BGII	Maharashtra, Gujarat, Madhya Pradesh	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 1.85 tonnes/ha, maturity 160–170 days.
MC 5516 BGII	Andhra Pradesh, Telangana, Karnataka, Tamil Nadu	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 2.47 tonnes/ha, maturity 160–170 days.
BIO 6524 BG II (BIO 6524 BG II)	Haryana	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 3.29 tonnes/ha, maturity 155–165 days.
BIO GHH 324-2 BG II (BIO 6024 BG II)	Maharashtra	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, yield 1.85 tonnes/ha, maturity 155–165 days.
BIO GHH 033-2 BG II (BIO 6033 BG II)	Maharashtra, Gujarat, Madhya Pradesh	Suitable for irrigated conditions, contains *cry1Ac* and *cry2Ab* genes, yield 1.86 tonnes/ha, maturity 155–165 days.
ACH-121-2 BG II	Gujarat	Suitable for rainfed conditions, contains *cry1Ac* and *cry2Ab* genes, seed-cotton yield 1.7 tonnes/ha, maturity 145–155 days.

(*Contd...*)

Variety	Area of adoption	Characters
Daftari-333 (BG II)	Gujarat	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for rainfed ecosystem, seed cotton yield 1.72 tonnes/ha, maturity 150–165 days.
Daftari-615 (BG II)	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for rainfed ecosystem, seed cotton yield 2.23 tonnes/ha, maturity 150–165 days.
ATCH-704 BGII	Gujarat, Maharashtra, Madhya Pradesh	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed- cotton yield 1.95 tonnes/ha, maturity 145–155 days.
ATCH-605 BGII	Gujarat, Maharashtra, Madhya Pradesh	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed- cotton yield 2.40 tonnes/ha, maturity 150–160 days.
CCH- 666 BGII	Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for rainfed ecosystem, seed- cotton yield 2.35 tonnes/ha, maturity 145–150 days.
ADIG (MC 5401) BGII	Andhra Pradesh, Telangana	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene, suitable for rainfed ecosystem, seed- cotton yield 2.29 tonnes/ha, maturity 150–160 days.
PCH 5677 Bt2	Gujarat, Maharashtra, Madhya Pradesh	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed cotton yield 2.10 tonnes/ha, maturity 150–160 days.
SRCH 207 BG II	Maharashtra, Madhya Pradesh, Gujarat	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed- cotton yield 1.70 tonnes/ha, maturity 140–145 days.
YC 7963 Bt2	Gujarat, Maharashtra, Madhya Pradesh	*Bt*-cotton variety with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed- cotton yield 1.10 tonnes/ha, maturity 140–150 days.
(JBG-4 BG-II) (G.Cot.Hy-24 BG II: Sorath Swet Kanak)	Irrigated (Central zone) areas of Gujarat, Maharashtra, Madhya Pradesh	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, yield 2.14 tonnes/ha, maturity 155–175 days.
Neo 1635 BG II (SZ)	All types of cotton growing soils of Andhra Pradesh, Telangana, Karnataka, Tamil Nadu	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for rainfed ecosystem, seed cotton yield 1.82 tonnes/ha, maturity 125–130 days.
Gold Star BG II	Irrigated low to high fertile soil conditions of Gujarat, Maharashtra, Madhya Pradesh, Rajasthan	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed cotton yield 2.10 tonnes/ha, maturity 155–165 days.
NBC-1821BG II (CZ)	Rainfed tracts of Maharashtra, Madhya Pradesh, Gujarat	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for irrigated ecosystem, seed cotton yield 2.00 tonnes/ha, maturity 150–160 days.
NBC-1103 BG II (SZ)	Rainfed tracts of Telangana, Andhra Pradesh, Karnataka, Tamil Nadu	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for rainfed ecosystem, seed- cotton yield 2.14 tonnes/ha, maturity 150–155 days.
SP7670 BGII (SZ)	Rainfed areas of Maharashtra, Madhya Pradesh, Gujarat	*Bt*-cotton hybrid with *cry1Ac* and *cry2Ab* gene suitable for rainfed ecosystem, seed- cotton yield 1.72 tonnes/ha, maturity 150–160 days.
Sugarcane (*Saccharum* spp. Hybrid)		
Co 15023 (Karan 15)	Uttar Pradesh (central and western), Uttarakhand, Haryana, Punjab, Rajasthan, Delhi	Suitable for early group under irrigated condition, average cane yield 89.17 tonnes/ha, CCS 12.16 tonnes/ha and sucrose 19.41% in juice, resistant to moderately resistant to red-rot.

(*Contd...*)

Variety	Area of adoption	Characters
Co 13013 (Akshaya)	Tamil Nadu, Kerala, Interior Andhra Pradesh, Telangana, Karnataka, Gujarat, Maharashtra, Madhya Pradesh	Suitable for mid-late group under irrigated condition, average cane yield 121.96 tonnes/ha, CCS 14.75 tonnes/ha and sucrose 19.01% in juice, tolerant to drought and salinity, moderately resistant to red-rot.
GNS-11 (Navya) (CoN 13072)	Gujarat	Suitable for early maturing group under irrigated condition, average cane yield 133.28 tonnes/ha, moderately resistant to wilt and red-rot, resistant to whip smut, a good ratooner.
VSI 12121 (VSI 08005)	Gujarat, Madhya Pradesh, Chhattisgarh, Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, Kerala	Suitable for growing under medium black to well drained with good fertility soil in Peninsular Zone under irrigated condition, fit for planting during autumn and spring seasons, average cane yield 124.7 tonnes/ha, CCS 18.22 tonnes/ha, sucrose 20.07% in juice, maturity 360–365 days, tolerant to drought and salinity stresses, moderately resistant to red-rot.
Haryana Ganna 160	Haryana	Suitable for autumn and spring planting, average cane yields 85 tonnes/ha, early maturity group (300 days), resistant to red-rot, non-lodging and multi-ratooner variety.
Jute (*Corchorus olitorius*)		
JROB 2	West Bengal, Odisha, Bihar, Assam, Parts of Uttar Pradesh, Tripura	A green-stem tossa jute variety specifically suited for biomass production beside its equal suitability for fibre production, average green biomass productivity 59 tonnes/ha with average fibre yield 3.2 tonnes/ha, fibre-crop maturity 110–120 days, biomass crop matures in 50–130 days depending upon the time of sowing, sown from March to August for biomass production and March to April as fibre crop, field resistance to stem rot, BHC and stem weevil.
JRCJ 11	West Bengal, Assam, Odisha, Bihar	Suitable to capsularis jute growing areas, optimum sowing period from 3rd week of March to 2nd week of April, average fibre yield 3.15 tonnes/ha, fibre maturity 110–120 days, days to seed maturity 135–150 days, can tolerate water logging to some extent at the later stage of crop growth, highly tolerant to Bihar hairy caterpillar.
Mesta (*Hibiscus cannabinus*)		
AMV 10 (AHS 286)	Andhra Pradesh, Odisha, Maharashtra, Bihar	Suitable to rainfed as well as irrigated conditions for mid-May to mid-June sowing, fibre crop matures within 140–150 days of sowing and its average fibre yield is 2.56 tonnes/ha, tolerant to major diseases and pest, i.e. foot and stem rot, aphids and mealy bug.

Forage and other crops

Seventeen high yielding varieties/hybrids of forage and other crops comprising 6 of oat, 4 of amaranth, 2 each of forage sorghum and pearl millet and 1 each of berseem, kalingda and *Sesbania* (*dhaincha*) were released for cultivation in different agro-ecologies.

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

Variety	Area of adoption	Characters
Oats (*Avena sativa*)		
HFO 427	Andhra Pradesh, Odisha, Maharashtra and Bihar	Suitable for irrigated conditions during *rabi*, average yield 32 tonnes/ha (green fodder), 6.7 tonnes/ha (dry fodder) and 1.04 tonnes/ha (grain), maturity 135 days.

(*Contd...*)

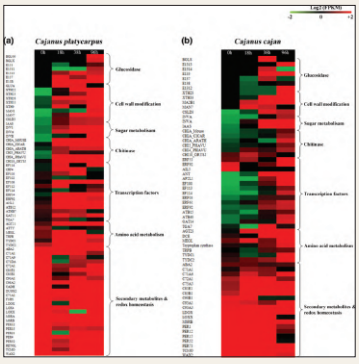
Variety	Area of adoption	Characters
HFO 607	Punjab, Haryana, Rajasthan, Tarai part of Uttarakhand	Suitable for irrigated conditions during *rabi*, average green fodder yield 61.5 tonnes/ha, dry fodder yield 13.1 tonnes/ha and grain yield 2.76 tonnes/ha, maturity 155 days, moderately resistant to *Helminthosporium* leaf blight, 9.2% crude protein and 56% dry-matter digestibility.
Pant Forage Oat 4 (UPO 10-2)	Uttarakhand (Low hills and Plains)	Suitable for normal fertility and irrigated conditions during *rabi*, average green fodder yield 34 tonnes/ha, dry fodder 7.5 tonnes/ha and grain yield 2.76 tonnes/ha, maturity 145 days, high leaf stem ratio (0.58), 9–11% crude protein, 58–60% dry-matter digestibility and high-protein yield (7.5–8 q/ha).
OL 1874 (OL14)	Punjab, Haryana, Rajasthan, Tarai part of Uttarakhand	*Rabi* fodder crop suitable for multicut system, high green fodder (73.77 tonnes/ha), high crude protein (14.7%), seed yield (1.9 tonnes/ha), moderately resistant against leaf blight.
OL 1896	Punjab, Haryana, Rajasthan, Tarai part of Uttarakhand	*Rabi* fodder crop suitable for single cut system, high green fodder (64.91 tonnes/ha), high crude protein yield (1.32 tonnes/ha), seed yield (2.70 tonnes/ha), moderately resistant to leaf blight.
OL 1876-2	Assam, Jharkhand, Odisha, Eastern Uttar Pradesh	*Rabi* fodder crop suitable for dual- purpose system, high green fodder (22.61 tonnes/ha), high crude protein (8.6%), seed yield (1.34 tonnes/ha), resistant to leaf blight.
Forage sorghum (*Sorghum bicolor*)		
CSH 43 (SPH-1881)	Haryana, Punjab, Uttar Pradesh, Rajasthan, Gujarat, Uttarakhand, Maharashtra, Tamil Nadu, Telangana, Karnataka	Suitable irrigated summer (spring) and rainfed *kharif* for timely and late (up to 30 July) sowing for green fodder production through 3–4 cuttings, average green and dry fodder yields of 96.52 tonnes/ha and 21.83 tonnes/ha, respectively; tolerant to foliar diseases and stem-borer.
Mega Sweet (SPH 1890) (ADV 6681)	All India	Single cut forage sorghum hybrid suitable for irrigated condition under medium to high soil fertility for normal sowing during spring and *kharif*, green-fodder yield 44 tonnes/ha, tolerant to stem-borer.
Forage pearl millet (*Pennisetum glaucum*)		
Nutrifast-ADV 961 (ADV0061)	Madhya Pradesh, Maharashtra, Gujarat	Multicut sorghum variety suitable for irrigated/rainfed conditions during *kharif* and summer, high green (97.49 tonnes/ha) and dry fodder yield (19.06 tonnes/ha), crude protein (1.46 tonnes/ha), seed yield (2.04 tonnes/ha), high per day productivity for GFY (8.47 q/ha/day) and DFY (1.59 kg/ha/day).
Harabhara (HTBH 4902)	Irrigated summer season in medium fertility soils of Telangana, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala	Suitable for multicut system in summer irrigated condition, high green (53.24 tonnes/ha) and dry fodder yield (11.38 tonnes/ha), crude protein (1.31 tonnes/ha), high per day productivity for GFY (6.63 q/ha/day) and DFY (1.39 kg/ha/day).
Berseem (*Trifolium alexandrinum*)		
BL 44 (PC 91)	Punjab, Haryana, Rajasthan, Uttarakhand, West Bengal, Jharkhand, Bihar, Eastern Uttar Pradesh, Odisha	Multicut fodder variety suitable for irrigated condition during *rabi*, high green [81.95 tonnes/ha (NWZ), 41.01 tonnes/ha (NEZ)], crude protein (18%), moderately resistant against stem rot and leaf blight.

(*Contd...*)

Variety	Area of adoption	Characters
Others		
Grain amaranth (*Amaranthus* spp.)		
Gujarat Amaranth 5 (SKGPA 61)	Gujarat, Rajasthan, Maharashtra, Jharkhand	Suitable for *rabi*, average grain yield 1.9 tonnes/ha, 11.85% protein, 7.71% oil, 14.4 mg/100 g iron and good amount of other minerals.
VL Chua 110	Uttarakhand hills	Suitable for rainfed organic ecology, average grain yield 0.80–1 tonne/ha, maturity 110–116 days, high protein (14.27%), calcium (221.5 mg/100 g) and total antioxidant activity (25.88 Mm/g DW).
Gujarat Amaranth 4(SKGPA 74)	Karnataka	Suitable for *kharif*, average grain yield 2.22 tonnes/ha, seeds contain 12.63% protein, 7.82% oil and possesses good mineral content.
Gujarat Amaranth 6 (SKNA 401)	Gujarat	Suitable for *rabi*, average grain yield 1.88 tonnes/ha, bold and white seeds with high protein, green stature inflorescence.
Kalingada (*Citrullus lanatus*)		
Gujarat Kalingada 2 (SKNK 1102)	North Gujarat, Rajasthan	Suitable for *kharif*, average seed yield 0.29 tonnes/ha, seeds contain higher amount of oil, crude protein, Ca, Fe, Mg and S.

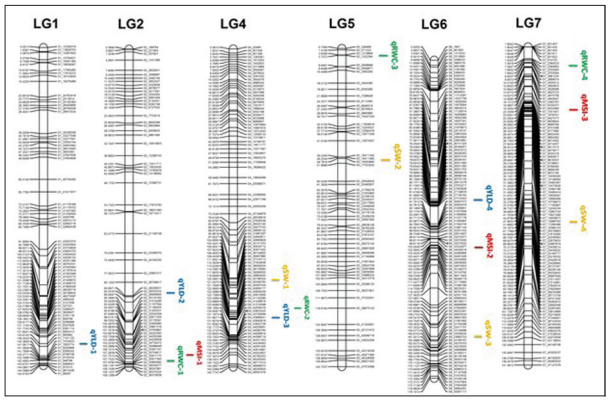
Identification of insect resistant genes from *Cajanus platycarpus*

Cajanus platycarpus, a non-crossable wild relative of pigeonpea, possesses resistance to polyphagous insect pest, *Helicoverpa armigera.* Hence, *C. platycarpus* was used for understanding the mechanism of resistance to *H. armigera* and identification of candidate genes to mitigate the menace of the herbivore. RNA-seq and differential gene expression analysis were carried out between *C. platycarpus* and cultivated pigeonpea cultivar, TTB 7, at different time points after challenge with the insect larvae. Fifteen herbivory response specific genes with >2-fold differential expressions have been selected. These genes with probable role in: (i) insect structural destruction; (ii) interference in digestion; (iii) reduction in availability of nutrients; and (iv) transcription factors have been shortlisted for validation. These putative insect resistance genes have been cloned from *C. platycarpus* into binary vectors and are being validated in *Nicotiana tabacum.*



Heat maps depicting differential expression of genes involved in plant–herbivore interaction in *C. platycarpus* and *C. cajan,* respectively.

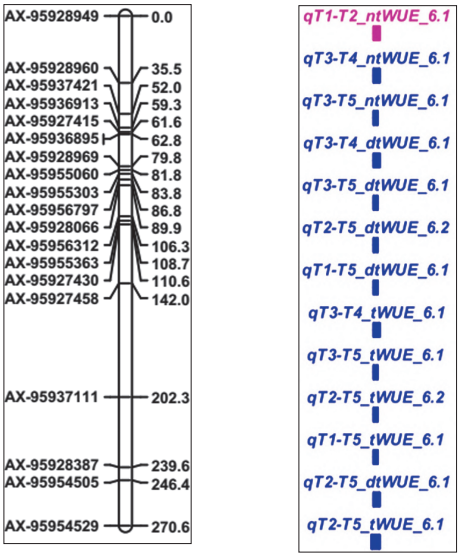
QTL mapping on drought-stress tolerance in chickpea: Genotyping-by-Sequencing approach was used for the large-scale SNP discovery and simultaneous genotyping of recombinant inbred lines (RILs) of an intra-specific mapping population (Pusa 362 × SBD 377) of chickpea contrasting for drought related traits. The chickpea genome annotation project database was used to delineate the location of the GBS derived 3,267 SNPs in the genomic regions: intergenic, genic (exons), intragenic (introns) and UTRs**.** The occurrence of both types of transitions- C/T and A/G was higher than any of the transversions. The SNP genotyping data was utilized to construct one of the most saturated intra-specific genetic linkage maps of chickpea having 3,267 SNPs on 8 linkage groups**.** The map was utilized to identify 15 quantitative trait loci (QTL) associated with drought traits



Location of QTLs on the genetic linkage map of chickpea developed from the cross Pusa 362 × SBD 377. QTLs are depicted as coloured vertical bars to the right of the linkage groups. MSI (Membrane Stability Index), RWC (Relative Water Content), SW (100 Seed Weight) and YLD (Yield under stress condition).

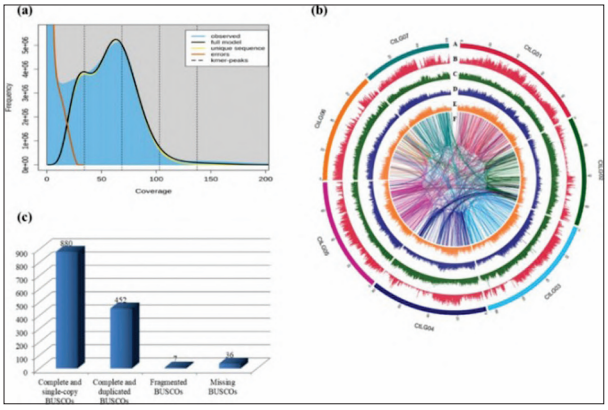
(membrane stability index, relative water content, seed weight and yield under stress condition) accounting for phenotypic variations ranging from 11.8–27.1%.

Phenomics of transpiration and water-use efficiency in rice: At Nanaji Deshmukh Plant Phenomics Centre (NDPPC), New Delhi, ML and AI aided Computer Vision methods such as SpikeSegNet for spike detection and counting in wheat, and leaf tip detection and counting methods in rice were developed in collaboration with ICAR–IASRI, New Delhi and IIT, Mumbai. Towards mapping of QTLs for components of transpiration and water use efficiency, 170 RILs of BVD109 × IR20 of rice were precision phenotyped. This set was also genotyped with 50K SNP genotyping Chip. Under irrigated conditions, three QTLs (qWUE 8.3 and qWUE 6.1 and qWUE 6.2) for WUE with PVE of 17.43%, 10.32% and 16.98% were mapped on chromosome 8 and 6, respectively. In confirmation to this, three QTLs related to day time water-use efficiency (qWUEd 6.2 and qWUEd 8.4 and qWUEd11.5) also located very close in the same location with high PVE of 17.15%, 18.39%, 10.16%, respectively. QTL related to night time WUE was mapped successfully in chromosome 8 (qWUEn 8.2) with high PVE% of 13.02%. Under drought stress, two QTLs related to whole day transpiration rate (qTRBM 6.3 and qTRPSA 6.4) have been mapped in chromosome 6 with high PVE value of 31.84% and 34.12%, respectively. These QTLs will be useful to elucidate molecular basis and genetic improvement of WUE in rice.



Identification of a QTL hotspot for transpiration and WUE traits in rice using phenomics

Chromosome scale reference genome of cluster bean (*Cyamopsis tetragonoloba*): A chromosome-scale reference genome assembly of clusterbean, from a high galactomannan containing popular guar (clusterbean) cultivar, RGC 936 was done. The initial assembly of 1,580 scaffolds with an N50 value of 7.12 Mbp was generated. Then, by anchoring these scaffolds to a high-density SNP map, a genome assembly of 550.31 Mbp was obtained in 7 pseudomolecules corresponding to 7

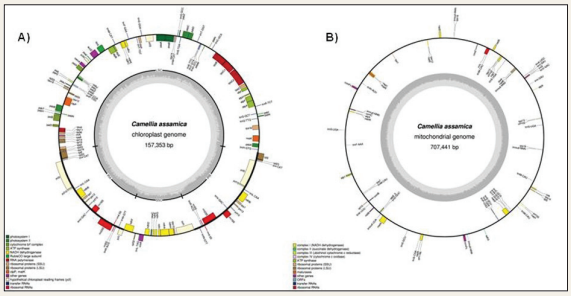


(a) The 31-mer frequency distributions of the sequencing reads, (b) The cluster bean genome features. Track A represents 7 pseudochromosomes. Track B to E represent the distribution of protein-coding genes, Retrotransposons, DNA elements and Simple sequence repeats, respectively. Track F represents gene duplications in the cluster bean genome. (c) Benchmarking Universal Single-Copy Orthologs (BUSCO) analysis of cluster bean annotated genes.

chromosomes with a very high N50 of 78.27 Mbp. In total, 34,680 protein-coding genes have been predicted in the guar (clusterbean) genome. The high-quality chromosome-scale clusterbean genome assembly will facilitate understanding of the molecular basis of galactomannan biosynthesis and aid in genomics-assisted breeding of superior cultivars.

Decoding of cell organelle genomes of popular Indian tea genotype, TV1

Using PacBio and Illumina Mate-pair reads, first ever reported chloroplast (cp) (157,353 bp) and mitochondrial (mt) genome (707,441 bp) of Indian tea (*Camellia assamica*) were successfully assembled and analyzed. The chloroplast genome comprised a typical circular quadripartite structure with 2 inverted repeats (IRa and IRb, 26,031 bp each), a large single copy (LSC) and a small single copy (SSC) region of 87,213 bp and 18,078 bp, respectively. Chloroplast genome comprised 126 genes while mitochondrial genome has 66 genes. The LSC-IR and SSC-IR junctions along with 6 randomly selected cp genes were validated and confirmed by PCR.

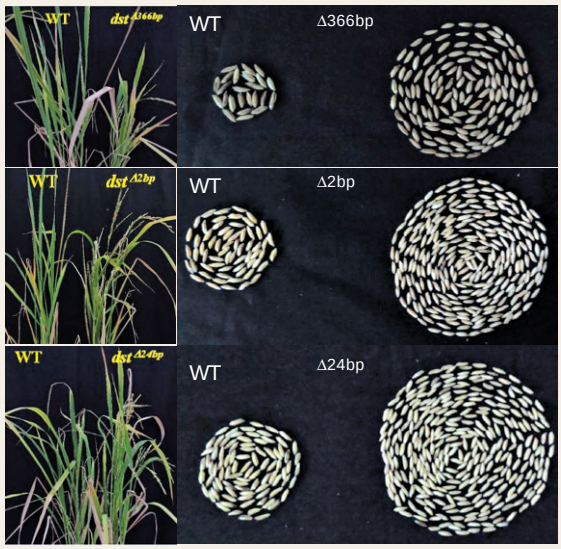


Map of the chloroplast genome (a) and mitochondrial genome (b) of Indian tea showing annotated genes with different functional groups that are color-coded on outer circle as transcribed clock-wise (*outside*) and transcribed counter clock-wise (*inside*). The inner circle indicates the GC content as dark grey plot.

Transgenics in pigeonpea for resistance to pod-borer, *Helicoverpa armigera*: Transgenics were

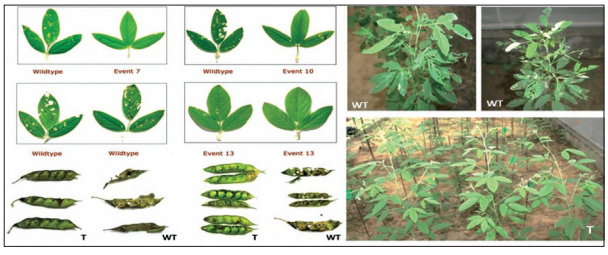
Genome editing for improvement of drought and salt tolerance in rice

Genome editing is a precision mutagenesis tool for genetic improvement of crops. CRISPR-Cas9 genome editing was used to develop mutants of *DST* (*Drought and Salt Tolerance*) gene encoding a Zinc finger transcription factor for improving salt and drought tolerance in rice. Three homozygous transgene free mutants were developed. WT and *dst* mutants grown in the same pot were exposed to three cycles of -90 kPa drought stress and recovered. Under these stress conditions, only about 25% WT plant survived, while *dst* mutants showed 100% survival. Further, *dst* mutants produced significantly higher yield than that WT plants both under non-stress and drought stress conditions. Similarly, WT and *dst* mutants grown in same pot were irrigated with 200 mM salt stress after panicle initiation, and were recovered after 15 days. All three *dst* mutants were more tolerant to salt stress and produced more grains as compared with wild-type MTU1010.



Genome edited *Drought and Salt Tolerance* (*DST*) gene knock out mutant of MTU1010 exhibit enhance tolerance to salinity stress. Salt stress (200 mM) was imposed after panicle initiation for 15 days, and then recovered; WT, MTU1010; $dst^{\Delta 366\ bp}$ $dst^{\Delta 2bp}$ and $dst^{\Delta 24bp}$ are mutants of MTU1010 with 366, 2 and 24 bp deletions, respectively.

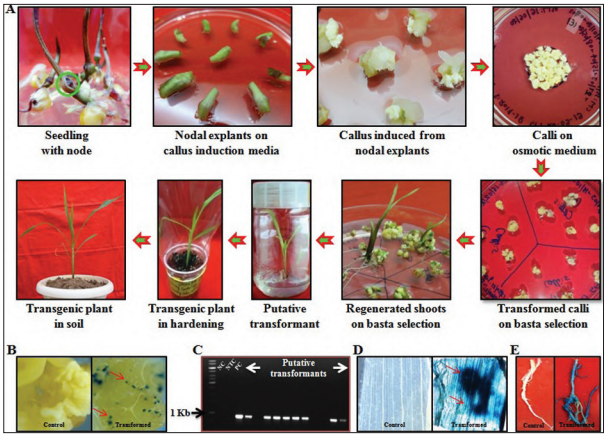
developed in pigeonpea expressing two independent *Bt* genes (*cry1AcF* and *cry2Aa*) to impart resistance to the devastating herbivore, *Helicoverpa armigera*. The transgenic plants (T) revealed high level of resistance against deliberate herbivore challenge as compared to non-transgenic wild type (WT) plants. Ten transgenics



Performance of transgenic *Bt* pigeonpea resistant to *Helicoverpa armigera*. WT, Non-transgenic wild type; T, transgenic plants.

events (5 each with *cry1AcF* and *cry2Aa*) were identified based on stringent bioefficacy and molecular characterization have been advanced to Event Selection Trials (approved by RCGM).

Development of a robust *in vitro* regeneration and transformation protocol for maize: Twenty eight diverse tropical maize (*Zea mays*) genotypes were evaluated for their embryogenic callus induction potential using mature seed derived two different explants (nodal explants and split-embryo region) under two different callusing media. Out of 28 genotypes, better callus induction was achieved in four genotypes (BML 6, DHM 117, DMRH 1301, and DMRH 1308) from nodal explants. Further, *in-vitro* regeneration was standardized using 22 different combinations of various auxins and cytokinins. Out of 28 genotypes, two recently commercialized and high yielding cultivars (DMRH 1301 and DMRH 1308) demonstrated the best callusing and regeneration capability with an average regeneration percentage of 60.4% and 53.6%, respectively. Using the nodal explants-derived embryogenic calli, the genetic transformation was successfully carried out using the 'Biolistic' approach, and up to ~5% transformation efficiency was achieved. Such an efficient, generalized and reproducible protocol has the potential to be a major tool for tropical maize improvement using transgenic and genome-edited techniques.



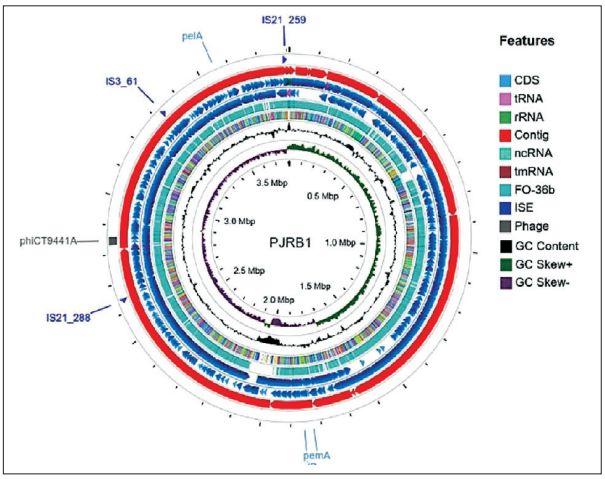
Standardization of *in-vitro* regeneration and transformation protocol. (A) Genetic transformation in tropical maize using mature seed derived nodal explants based calli and (B-E) molecular confirmation of putative transformants. (B) GUS expression in calli 10 days after biolistic transformation. (C) PCR analysis using β-*gusA* specific primers. GUS expression in leaves (D) and roots (E) from PCR positive plants.

Identification of resistant sources against fall armyworm (FAW), *Spodoptera frugiperda:* Towards the identification of resistant sources against FAW, 90 lines were evaluated under artificial infestation by releasing 20 neonate larvae/plant at the 5–6 leaf stage during *kharif* 2021. Three genotypes, viz. CML 44 BBB (3.4), DML 163-1 (3.5), IML 16-248 (4.0) recorded significantly lower Davis score on 1–9 scale. Genotype DMRE 63 which was found promising against FAW under choice condition during previous seasons was re-evaluated under no-choice condition through artificial

Identification of resistant sources against fall armyworm (FAW). (A) Genotype screening plots, (B) Artificial release of FAW neonates at 5–6 leaf stage and (C) Screening of DMRE 63 under no-choice condition.

infestation and has recorded significantly lower Davis score of 3.6.

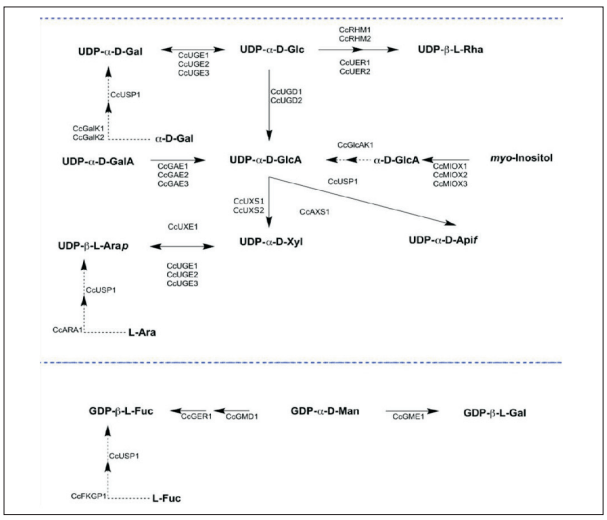
Genome sequencing of microbes of microbial-retting consortium: To be suitable for high valued diversified products, the quality of jute fibre needs further improvement through efficient retting process with a microbial-consortium 'CRIJAF SONA'. Genome sequences of these jute retting microbes have been carried by ICAR-CRIJAF, Barrackpore. The in-depth genomic analysis significantly revealed three different species of *Bacillus* constitute the consortium strains. The genome sizes of these strains are ~3.8 Mb with 3729 to 4002 protein coding genes. The sequence data has been submitted to the National Centre for Biotechnology



Genome sequencing of microbes of microbial-retting consortium

Information (NCBI) database of NIH, USA. Genome sequencing also confirms that retting bacteria degrades pectin, hemicellulose and other non-cellulosic materials, non-harmful for fibre. The bacterial strains are also non-toxic and thus the retting water with microbial strains can successfully be used for irrigation purpose. The genes for degrading pectin, hemicellulose and other non-cellulosic materials can be altered for enhanced retting efficiency and shortening the retting duration with minimal water usage. This will also open up an avenue to characterize the enormous diversity of retting microbial population at the metagenome scale and incorporate other strains to complement the consortium.

Reconstruction of pectin biosynthesis pathways in jute: Pectin is the primary target of pathogenic microbes attacking jute plant and the microbial community during the retting of jute. Understanding pectin biosynthesis pathway can help in modulation of the pathways to increase plant defense and selection of appropriate microorganism to accelerate the retting process. The pectin biosynthesis pathways were resolved for the first time in a fibre crop from a bast transcriptome resource of jute. Three major routes, UDP-sugar interconversion, GDP-sugar interconversion and salvage pathways are operational in both *C. olitorius* and *C. capsularis* that employ 17 genes to synthesis the precursors of pectin polymers. It was observed that the pectin biosynthesis pathways are well-conserved in higher plants, particularly in species where special pectic polysaccharides (mucilage) are produced. The metabolic flux of pectin biosynthesis is driven towards more-complex rhamnogalacturonan (RG) pectin formation in *C. olitorius*. The salvage pathways ensured a continuous supply of UDP-Rhamnose in *C. olitorius*, making its pectin more enriched with RG compared to that of *C. capsularis*. Hence priority should be given to identify RG-degrading microorganisms for faster retting of jute fibre.



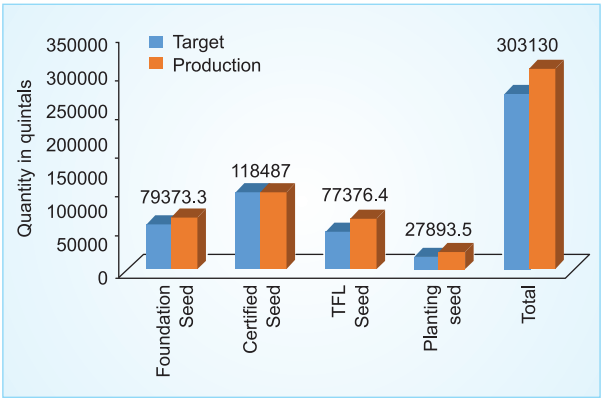
Pectin biosynthesis pathways in jute showing the formation of pectin monomeric units

Seed Production

Breeder seed production: During 2020–21, total breeder seed production in field crops was 1,15,517.2 q against the indent of 80,938.8 q. The major share in total breeder seed production belongs to cereal crops, i.e. 72,485.2 q against indent of 40,751.6 q. Under pulse crops a total of 17,590.4 q breeder seed was produced against the indent of 15,448.3 q. In oilseeds, total breeder

seed production was 24,638.8 q against the indent of 24,027.6 q. Breeder seed produced in case of fibre crops was 32.6 q against the indent of 14.8 q and in forage crops, 770.2 q was produced against the indent of 696.5 q.

Quality seed production: During the year, total production of quality seed including all classes was 3,03,130.2 q against the target of 3,32,055.5 q. Production comprised 79,373.3 q of foundation seed, 1,18,487.0 q of certified seeds, 77,376.4 q of truthfully labeled seed and 27,893.5 q of planting material of field crops. In addition, 356.6 lakh planting material and 8.5 lakh tissue culture plantlets were produced against the targets of 327.3 and 2.6 lakh, respectively.



Quality seed production during 2020–21

HORTICULTURE

A total of 98 varieties of horticultural crops were identified and notified by the Central Sub-Committee on crop standards, notification and release of varieties for Horticultural crops in its 28th meeting on 28 October 2020.

These include 15 in fruit crops (sweet orange-1, acid lime-2, grapes-2, mango-5, banana-5), 29 in vegetable crops (brinjal-5, chilli and capsicum-5, one each in radish, cauliflower, bottle gourd, cucumber, ridge gourd, spine gourd, Frenchbean, long melon, pea and beans-5; tomato-5, yams-7, Colocassia/arvi including Sakhen bunda-3), eight in plantation crops (coconut-6, arecanut-1 and oil palm-1), nine in spices (three each in turmeric and coriander and one each in celery, fenugreek and ajwain), and 11 in flowers (Aster-1 and five each in marigold and chrysanthemum).

Fruits and nuts

Development and characterization of apple hybrids: A total of five apple hybrids have been developed such as Ammol (Ambri × Mollies Delicious) for early maturity, Ambrit (Ambri × Top Red) with typical ambri flavour; Priame (Prima × Ambri), Pride (Prima × Red Delicious) and Pritor (Prima × Top Red) with scab resistance.

Plantation crops

Coconut: Kalpa Ratna is suitable for tender nut, copra and inflorescence sap production and notified by the Central Variety Release Committee for cultivation in Kerala, Karnataka and semi-arid region of Tamil Nadu. The productivity is 133 nuts/palm/year, with estimated copra yield of 4.5 kg/palm/year. The tender fruits are green and contain 520 ml tender nut water with 6°Brix TSS.

High yielding Kalpa Ratna coconut variety

Kalpa Raja is a promising tall variety for large scale cultivation in the root (wilt) disease prevalent tract. Kalpa Raja was produced by crossing high yielding and root (wilt) disease-free West Coast Tall (WCT) palms. The healthy palms gave 158 nuts/palm production as against 65 nuts in diseased palms.

Arecanut: Shatamangala, is a high yielding and dual-purpose arecanut variety developed from the indigenous

Shatamangala (*left*), Shatamangala variety bunch (*right-top*) and Shatamangala variety garden (*right-bottom*)

Ammol
Early maturity

Ambrit
Ambri flavour

Priame
Scab resistant

Pride
Scab resistant

Pritor
Scab resistant

Dwarf varieties of cashew identified

Nethra Vaaman is slow growing (< 2 m height in 10 years), precocious and medium nut yielder with small nut (< 6 g) and attractive apple. The accession suits well for ultra-density planting system (2.5 m×2.5 m and 3 m×3 m spacing) with 1–2 kg yield per plant.


KAU Nihara, a dwarf cashew variety suited for urban and peri-urban homesteads of Kerala with intensive branching and having a nut size of 5–7 g and 2 kg/plant productivity was identified.

accession. Shatamangala variety has been notified for cultivation in Karnataka, North Bengal and Gujarat. The yield is 3.26 kg dry tender processed nuts/palm/year or 3.96 kg dry kernel/palm/year.

Oil palm variety identified for release at CVRC: Godavari Swarna (NRCOP 4) has 26.87 tonnes/ha/yr fresh fruit bunch yield, 5.71 tonnes/ha/year mesocarp oil yield and recommended for cultivation in Andhra Pradesh.

Two oil palm varieties identified for release at SVRC: Godavari Ratna (NRCOP 2) has 22.44 tonnes/ha/year fresh fruit bunch yield with 18.31 kg bunch weight and 5.36 tonnes/ha/year mesocarp oil yield, and notified for cultivation in coastal region of Maharashtra and Goa.

Godavari Gold (NRCOP 17) has 27.23 tonnes/ha/year fresh fruit bunch yield, 11.74 bunches/palm with 5.79 tonnes/ha/year mesocarp oil yield and identified for cultivation in coastal Tamil Nadu under irrigated conditions.

Vegetable crops

Chilli hybrids resistant to ChLCV: Arka Tejasvi F_1 hybrid is suitable for dry small (Teja) segment, plants medium tall and spreading, fruits pendent: 7–8×1–1.1 cm, firm, highly pungent (90–95000 SHU), green and turns deep red (90–100 ASTA) on maturity, medium wrinkled and resistant to powdery mildew and ChLCV. The potential is 75–90 q dry chilli yield/ha.

Arka Yashasvi F_1 hybrid is suitable for dry medium segment, plants tall and spreading, fruits pendent: 9–10×1.2–1.4 cm, firm, medium pungent (40–50,000 SHU), green and turns deep red on maturity (90–100 ASTA), fruits medium wrinkled and tolerant to powdery mildew, RKN (root knot nematodes) and resistant to ChLCV. The potential is 75–90 q dry chilli yield/ha (or) 250 q green chilli yield/ha.


Arka Saanvi F_1 hybrid is suitable for dual small (green and dry) segment, plants medium tall and spreading, fruits pendent: 7–8×1–1.2 cm, firm, medium pungent (50–60,000 SHU), green and turns red (80–90 ASTA) on maturity, medium wrinkled and resistant to ChLCV. The potential is 75–90 q dry chilli yield/ha (or) 250 q green chilli yield/ha.


Arka Tanvi F_1 hybrid is suitable for dual medium segment, plants tall and spreading, fruits pendent: 9–10×1–1.1 cm, firm, medium pungent (60–65,000 SHU), green and turns deep red (90–100 ASTA) on maturity, dry fruits wrinkled and tolerant to powdery mildew, RKN (root knot nematodes) and resistant to ChLCV. The potential is 75–90 q dry chilli yield/ha (or) 250 q green chilli yield/ha.


Arka Gagan F_1 hybrid suitable for green upright segment, plants medium tall and spreading, fruits pendent: 7.5–8.5×1–1.1 cm, firm, highly pungent (1–1.2 lakh SHU), green, medium wrinkled and tolerant to root wilt, RKN (root knot nematodes) and resistant to ChLCV. Yield potential is 2,500 q green chilli/ha.


Watermelon: Arka Shyama is an icebox segment watermelon variety, with dark red, crispy, sweet (TSS-

12%) pulp, oblong fruit shape, 3–4 kg weight, dark greenish black rind, and early harvest (65–70 days). The yield potential is 62.8 tonnes/ha.

Indian (Dolichos) bean/Sem: Arka Neelachal Pushti, is high yielding, pole type, round podded variety. The pods are rich in protein (4.61 g/100 g) and micronutrients (iron: 15 ppm, zinc 37 ppm). Duration of crop is 95 days from sowing to green harvest. *Rabi* season is ideal for its cultivation in Eastern India. Average yield is 24 tonnes/ha in 120 days.

Varieties of vegetable crops for release and notification

Brinjal (Round): The fruits of GNRB 1 are round, dark purple. It has less incidence of little leaf disease, has less number of whitefly and jassid population per leaf. It contains total phenol (2.07%), TSS (3.09%), Vitamin C (2.90 mg/100 g), anthocyanin (475.3 mg/100 g), β-carotene (0.77 mg/100 g), crude fibre (1.42%) and glycoalkaloids (0.16%). This variety is recommended for Zone-I (Himachal Pradesh, Jammu and Kashmir and Uttarakhand).

IVBR 17 is light green, round fruited variety with green calyx, tolerant to excess soil moisture stress. Early fruiting variety bearing 25–35 fruits/plant. Average fruit weight is 275 g and has yield potential of 580–600 q/ha. The variety is identified for zone IV (Punjab, Uttar Pradesh, Bihar and Jharkhand).

Carrot (Tropical): Roots of VRCAR 186 are attractive, triangular, red, 21–23 cm in length, 110–125 g, ready to harvest in 90–100 days. TSS 8.5–9°Brix. It is suitable for salad, juice and halwa purposes. Marketable root yield 300–350 q/ha. Recommended for Zone VII: Semi-Arid Lava Plateau and Central High Lands (Madhya Pradesh, Maharashtra and Goa) and Zone VIII: Humid to Semi–Arid Western Ghats and Karnataka Plateau (Karnataka, Tamil Nadu, Kerala and Puducherry).

Cauliflower (Early): Sabour Mukta is suitable for growing as early cauliflower, matures in 60–65 days after transplanting. The curds can be harvested in October–November. Curd yield is 189 q/ha with the potential yield of 372 q/ha. Plants are 55–60 cm in height and 75–80 cm in diameter with semi-erect waxy leaves. Curds are compact, creamy white, partially covered by inner leaves. Curd weight ranges from 500–550 g/plant under optimum growing conditions. It has been recommended for cultivation in Zone V (Odisha, Chhattisgarh and Andhra Pradesh).

Cowpea (Bush): VRCP 12 is a bush type variety with erect growth habit and photo-insensitivity. Suitable for sowing in rainy and spring-summer seasons. It flowers in 40–45 days after sowing. Pods are 32–35 cm long, dark green, tender and free from parchment layer. Yield potential 140–160 q/ha. Identified for cultivation in Zone IV (Punjab, Uttar Pradesh, Bihar and Jharkhand).

Dolichos bean (Bush): VRBSEM 3-Days to first picking: 80–85 days, Peak fruiting period: December to March. DYMV disease free in cropping period with temperature tolerance up to 35°C. Yield: 360 q/ha in five pickings. Identified for cultivation in Zone VI (Rajasthan, Gujarat, Haryana and Delhi), Zone VII (Madhya Pradesh, Maharashtra and Goa) and Zone VIII (Karnataka, Tamil Nadu, Kerala and Puducherry).

VRBSEM 9— Days to first picking: 70–75 days. Peak fruiting period: December to February. Dolichos Yellow Mosaic Virus disease free in cropping period, temperature tolerance up to 35°C. Yield: 350 q/ha in five pickings. Identified for cultivation in Zone VII (Madhya Pradesh, Maharashtra and Goa).

Dolichos bean (Pole type): IS-2016-9—Attractive pods are borne @10–12 pods/cluster. Pods are 12–15 cm long with dark green colour and violet suture. At harvest, pods have succulent seeds inside and make excellent cooking quality and taste. Tolerant to bruchids,

aphids and resistant to podborer complex. Moderately resistant to mosaic. Average yield is 166 q/ha and potential yield is 210 q/ha. Identified for cultivation in Zone VII (Madhya Pradesh, Maharashtra and Goa).

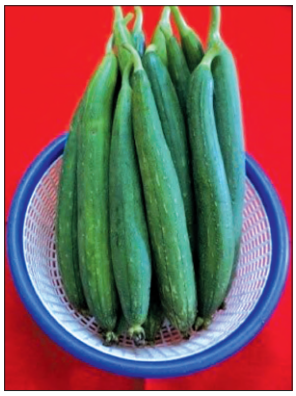
Bottle gourd: Narendra Kamna—Fruits are light green, long straight (35–40 cm) with a fruit girth of 21–25 cm. Fruit weight 1.5 kg, ready for harvest after 55–60 days after sowing. This is long fruit type variety with yield potential of up to 542.2 q/ha with national average 270.83 q/ha (Punjab, Uttar Pradesh and Bihar). Suitable for distant markets. It is suitable for cultivation during *zaid* and *kharif*. It is resistant to downy mildew and powdery mildew under field condition. It is recommended as a high-yielding long fruited variety for release in Zone I (Jammu and Kashmir, Himachal Pradesh and Uttarakhand) and VIII (Karnataka, Tamil Nadu and Kerala).

French bean (Bush)

VRFBB 91 is bush-type, early, short duration, flowers at 32–35 days after sowing. Pods are green and bright, fleshy, tender, straight, cylindrical and free from parchment. Bears about 20–25 pods/plant. Resistant to sclerotinia rot (*Sclerotinia sclerotiorum*). Tender pod yield potential is 125–150 q/ha. Recommended for Zone I: Humid Western Himalayan Region (Jammu and Kashmir, Himachal Pradesh and Uttarakhand).

Pumpkin: VRPK 230 is an early maturing variety, having 2.5–3 kg fruit weight with 3 to 4.5 fruits/plant having 3 to 3.25 cm thick flesh. Carotenoid content 2.6 mg/100 g fruit. Productivity 350–400 q/ha. Recommended for Zone V (Chhattisgarh, Odisha and Andhra Pradesh).

Sponge gourd: VRSG 195—Fruits dark green, 20–30 cm long, straight and with 3.25–3.75 cm diameter. Fruit weight 150–175 g, first harvest in 42–45 days from date of sowing. Productivity 150–200 q/ha. Resistant to Sponge Gourd Mosaic and tolerant to downy-mildew disease under field condition. Identified for release and notification for cultivation in agroclimatic Zone-IV (Punjab, Uttar Pradesh, Bihar and Jharkhand) and Zone-VI (Rajasthan, Gujarat, Haryana and Delhi).



Hybrids developed

Brinjal (Long): Kashi Manohar (IVBHL 20)—Light purple, medium long fruited hybrid with green calyx. Early fruiting hybrid bears 90–100 fruits per plant. Average fruit weight is 93 g having yield potential of 625–650 q/ha. The hybrid is identified for Zone VII (Madhya Pradesh and Maharashtra).

Watermelon: NWMH 945—Fruits black, oval with 4–5 kg weight and 13.5° Brix. Early maturity and fruit ready to harvest within 70–75 days after sowing. Very dark red, compact, crispy flesh. Highly tolerant to *Fusarium* wilt, bud necrosis virus and gummy stem blight diseases.

Resistant varieties of vegetables developed

Brinjal (bacterial wilt): Kalinga Brinjal 131 (BB 67) is a selection from Kanderpur local from Cuttack, Odisha. Fruits are oblong, deep green with

white stripes. It bears 2–3 fruits in a cluster. It matures within 85–90 days after sowing. The average yield is 185.52 q/ha and potential yield is 430 q/ha. It is resistant to bacterial wilt.

Arka Avinash (IIHR-37-36-4-20) brinjal— Plants are tall and semi-spreading having green foliage; fruits are green long and borne in clusters with fleshy green calyx and have less seeds and having characteristics slow seed maturity and early in fruit picking (52 days) and has high level of resistance to bacterial wilt and yields 40–42 tonnes/ha in 120 days. It has been identified for release for Zone VIII.

Tuber crops

Potato: K. Kiran (HT/7-1329, CP4803) is a medium maturing (80–90 days) table variety with high yield (30–35 tonnes/ha) potential. This is identified for cultivation in Uttar Pradesh, Bihar, Haryana, Punjab, Uttarakhand, Gujarat, Odisha and Maharashtra.

MS/11-664 is a new red peeled, medium maturing table purpose hybrid (Kufri Kanchan × Kufri Khyati) with 35–38 tonnes/ha tuber yield. It possesses attractive red ovoid tubers with shallow eyes and cream flesh. It is field resistant to late blight. Hybrid retains excellent red colour even after storage. It is recommended for release in North Indian plains (central and eastern plains).

Sweet potato hybrids: SPH 38/46 has cream flesh with anthocyanin content of 10 mg/100 g, medium starch (18%) and excellent culinary quality.

SPH 110/28 is a biofortified hybrid clone identified with both anthocyanin (50 mg/100 g) and β-carotene (6 mg/100 g).

Greater yam: TGy 14-6 (Da H 9-196) is a high-yielding greater yam variety recommended for cultivation in Kerala. It has more yield (41 tonnes/ha) and anthracnose disease tolerance. It has excellent cooking quality with good organoleptic score (8), medium dry matter (29–33%), starch (20–22%) and crude protein (5–6%).

Cassava

T Ca 14-5 (8 S 501) with Cassava mosaic disease resistance has been recommended for Kerala, Tamil Nadu, Andhra Pradesh for industrial use. It is a high-yielding (51 tonnes/ha) variety with medium starch content (28%). It also has high Drought Tolerance Index value (1.54) under deficit water stress conditions.

8 S 501-2, resistant to CMD and recommended for central release for Kerala, Tamil Nadu and Andhra Pradesh for Industrial use.

Da H 9-196- Field View

Hati Aloo, with 15–20% increase in tuber yield over local check variety and good cooking quality has been recommended for central release for the states of Chhattisgarh and Andhra Pradesh.

IK-DIO-04-54, has been recommended for central release for Chhattisgarh, Maharashtra, Rajasthan, Manipur and Assam. Da H9-196 has been recommended for the state of Kerala. The tuber yield is found to be 40% more than the control, Sree Karthika. Tuber flesh colour is white with good cooking quality.

Kovvur collection, has been recommended for the state of Andhra Pradesh. This is high yielding, almost 50% increase in tuber yield over check varieties, with light creamy flesh and medium cooking quality.

Spices

Ginger: IISR Vajra, is a clonal selection (Acc. 247) with bold and plumpy rhizomes having 26.4 tonnes/ha fresh yield potential, recording 17% increased yield over national check. This variety has less fibre (5.67%), more essential oil (2.15%), oleoresin (7.26%) and dry recovery (20.7%). It has desirable flavour with high zingiberene (29.83%). The variety is recommended for cultivation in Kerala, Karnataka, Odisha and West Bengal.

The ginger variety: Gujarat Navsari Mango Ginger-2 was released in 2021 for cultivation in Gujarat. It gives 31.17 tonnes/ha fresh rhizome yield, 19.53% dry rhizome, 97.9% powder recovery, 3% total oil content besides being resistant to rhizome rot and moderately resistant to leaf blight diseases.

Turmeric: CG Raigarh Haldi-3 has 27 tonnes/ha productivity with 37.2% increase in rhizome yield over national check IISR Prathibha (19.9 tonnes/ha), suitable for cultivation in Chhattisgarh, Andhra Pradesh, West Bengal, Uttar Pradesh, Odisha, Gujarat and Tamil Nadu. It has 25.8% dry recovery, 3.78% curcumin, 4.8% essential oil and 10.64% oleoresin. It is moderately resistant to *Colletotrichum* leaf spot and *Taphrina* leaf blotch.

Gujarat Navsari Turmeric 3 was released for cultivation in Gujarat. It gives 32.89 tonnes/ha fresh rhizome yield, 18.6% dry rhizome recovery, 88% powder recovery, 3.3% curcumin and 4.56% oleoresin content.

Fennel: RF-289 (Karan Sounf 1) is a medium maturity, long and bold seeded variety moderately resistant to Rumularia blight disease.

Coriander: CG Raigarh Dhaniya 3 (RCC 12-7) is suitable for both leafy as well as seed purposes with a pleasant smell, medium seeds and with dark green leaves.The seeds have high volatile oil content (0.47%, i.e. 9.57 l/ha) and moderately resistant to powdery mildew and aphids. It is recommended for Chhattisgarh, Madhya Pradesh, Rajasthan, Bihar, Uttar Pradesh, Haryana, Gujarat, Uttarakhand, Andhra Pradesh and Tamil Nadu.

Ajmer Green Coriander 1 (AGCr-1)— It has been released at state level for Rajasthan. It was developed for only leaves purpose and also well grown in shade net in summer (off-season). Its green leaf and seed contain 0.05% and 0.36% essential oil, respectively. These also contain AGCr-1 Beta hydroxyl tibolone 26.93 mg/l. It takes 50–60 days for first cutting and gives 74.3 q/ha green leaves yield in *rabi*. The plants have tolerance to powdery mildew.

Fenugreek: Hisar Methi-273 is a fenugreek variety with high yield potential (22–25 q/ha), resistant to downy mildew and tolerant to powdery mildew.

Gujarat Methi 3 is less prone to lodging and powdery mildew disease, 33.7–42.6 pods/plant and more test weight (13.3 g).

Ajwain: Lam Ajwain 3, yields 10 to 12 q/ha in 140–150 days with yield advantage of 29.2% over national check, suitable for cultivation in Andhra Pradesh, Gujarat and Rajasthan. It has 7.8% volatile oil content and suitable for essential oil producing industries having essential oil yield of 30.7%; with attractive brown- and bold-seeds.

Ajmer Ajwain-73 (AA-73)— It takes 165–170 days to maturity and gives seed yield of 10–11 q/ha. Seed contains 9.15% total oil and 6.38% essential oil. It has tolerance to root rot under field conditions.

Nigella: Ajmer Nigella-1 (AN-1) takes 145–150 days to maturity and gives seed yield of 9 q/ha. Seeds total oil fraction contains 21.14% 9-Octadecenoic Acid (Oleic Acid), 3.32% Octadecenoic Acid (Oleic Acid), Cis-11,


3.14% 14-Eicosadienoic Acid. It is tolerant to root rot under field condition.

Celery: Ajmer Celery 2 (ACel 2) has been released


for Rajasthan. It takes 120–125 days to maturity and gives 8.74 q/ha seed yield. Seeds of ACel 2 contain 6.74% essential oil which is 17% more than check variety ACel 1.

Mushrooms

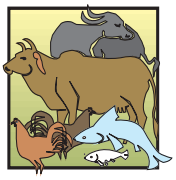
In Button mushroom strain NBS 5-1084 had 10% increased yield over control followed by NBS 5-773 with 8.60% yield increase.

In paddy straw mushroom, DMRO 1072 was recommended for national release and DMRO 995 for state release in Tamil Nadu.

In oyster mushroom, strain H3 (BE 68.44%) was recommended for release.

In shiitake mushroom, DMRO 327 strain was recommended for release for commercial cultivation.

In addition, a hybrid shiitake mushroom with 51.16% biological efficiency from two flushes was developed. ❑



6. Livestock Improvement

Cattle

AICRP on cattle improvement: Under the Indigenous Breeds Project (IBP), 6,500 Kankrej and 7,219 Gir cows were registered in their native tract. During the period, 4 sets in Gir (33 bulls), Kankrej (35 bulls), and Sahiwal (35 bulls) were introduced, of which the first set of 22 bulls (6 Gir, 8 Kankrej, and 8 Sahiwal) were evaluated for their genetic merit. In comparison to the baseline information, 36, 24, and 20% improvement in daughter's milk yield in the first set was achieved in Gir, Sahiwal, and Kankrej breeds of cattle, respectively. The average 305 days milk yield of elite cows maintained at germplasm (GP) units was recorded as 3,382.31±56.29 kg in Kankrej, 3,619.91±62.42 kg in Gir and 3,161.70±56.29 kg in Sahiwal which covers almost 50% of elite females maintained in the herd. A total of 769,049 semen doses of Gir (271,268), Kankrej (243,400) and Sahiwal (254,381) breeds have been frozen since inception. A total of 10,662 daughters (Gir 6,359), Kankrej (3,199) and Sahiwal (1,104) have been born in four sets since inception.

Field progeny testing programme: Under the programme of crossbred Frieswal (Holstien Friesan × Sahiwal), 25,323 artificial inseminations (AIs) were done, of which 4,140 female progenies were born; 1,209 daughters reached the age at first calving, of which 1,080 completed their first lactation milk yield. The average first lactation 305 days milk yield of the Frieswal^{TM} progenies increased by 60.35% in KVASU (1,958.4 kg to 3,140.43 kg), 42.86% in GADVASU (2,697.8 kg to 3,854.3 kg), 10.9% in BAIF (2,930.4 kg to 3,250 kg), and 41.64% in GBPUA&T (2,494.8 kg to 3,533.7 kg) centres covered field areas.

A total of 57,879 frozen semen doses of Frieswal^{TM} bulls have been maintained at the Frieswal germplasm unit (male) and 48,704 doses were made available to progeny testing program, various developmental agencies, para-vets and farmers for cattle improvement.

Sheep

At the farm, in Avishaan flock, ewe productivity efficiency (EPE) was 4.22 and 22.90 kg at birth and 3 month of age, respectively. The prolificacy in Avishaan ewes was 66.34% with litter size of 1.69. The average daily milk yield in ewes during the autumn lambing was 784 g. Since last three years, lambs born were 100% *FecB* gene carrier suggesting segregation of *FecB* gene in the progenies as a major gene. In field, 58 lambs were born out of 31 lambing of Avishaan ewes with a prolificacy of 71% and litter size of 1.87.

Muzzafarnagari flock

Distribution/sale of superior breeding rams and ewe covered

Unit (Breed)	No. of rams			Breedable ewes covered
	Distributed/ Redistributed	Sold	Total	
Mandya	52	76	128	2,219
Mecheri	31	100	131	2,250
Sonadi	71	00	71	1,620
Malpura	15	78	93	590
Total	169	254	423	6,679

Performance of farm and field sheep flocks

Breed	Mean body weight (kg)				Lambing (%)	Annual GFY (g)
	Birth	3 M	6 M	12 M		
Farm units						
Marwari	2.98±0.04	15.82±0.17	25.29±0.30	34.22±0.47	86.59	1217.79±25.63
Muzaffarnagari	3.81±0.04	16.30±0.18	25.97±0.25	37.75	80.00	815.00
Deccani	3.24±0.01	14.51±0.15	24.26±0.20	29.36±0.30	85.00	949.35±8.20
Nellore	2.63±0.03	13.41±0.52	21.30±0.22	24.71±0.21	89.62	NA
Field units						
Madras Red	2.56±0.02	10.33±0.07	14.44±0.09	19.64±0.16	75.00	NA
Magra	2.94±0.01	14.97±0.05	22.72±0.06	28.07±0.10	78.01	NA

Performance of farm and field flocks of different breeds

Breed	Flock	Mean body weight (kg)				% Lambing (Av. basis)	Annual GFY (g)
		Birth	3 M	6 M	12 M		
Mandya	Farm	2.21±0.01	11.32±0.06	16.19±0.08	22.39±0.11	96.24	587.65±7.85
	Field	2.15±0.01	10.93±0.02	15.75±0.04	21.49±0.05	97.56	512.54±5.72
Mecheri	Farm	2.65±0.03	12.00±0.25	15.77±0.53	22.32±0.64	90.50	NA
	Field	2.55±0.04	11.37±0.10	14.24±0.17	NA	90.00	NA
Sonadi	Farm	2.99±0.06	11.45±0.54	21.37±0.96	27.32±0.30	88.00	04.92±22.28
	Field	2.59±0.01	10.92±0.09	16.17±0.14	22.49±0.38	67.28	NA
Malpura	Farm	3.17±0.03	16.38±0.18	24.08±0.40	31.73±0.28	82.57	939.02±0.02
	Field	3.34±0.01	13.83±0.06	19.16±0.25	33.22±1.21	62.46	402.00±0.00

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 Agriculture/Veterinary Universities.

A total of 535 male and 192 female sheep of different breeds were sold for genetic improvement of farmer's flock.

Mega Sheep Seed Project (MSSP): The project has four cooperating units, viz. 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.

Goat

Breed improvement in field conditions: Improved Jamunapari, Barbari, Jakhrana goats were supplied for genetic improvement of germplasm in farmers' field.

Jamunapari goat: The averages age at first service (AFS), weight at first kidding (WFK), age at first kidding (AFK) and gestation period (GP) were 760.45±44.39 days, 33.80±0.69 kg, 931.89±51.44 days and 152.87±3.60 days, respectively, which showed desirable and significant improvement in reproductive traits. The overall mean of milk yield in 90 days and 140 days was 75.38±1.84 and 111.46±2.99 litres, respectively with lactation length of 161.04±3.24 days.

Barbari goat: The least squares means for average age at first service (AFS), weight at first service (WFS), weight at first kidding (WFK), age at first kidding (AFK), first kidding interval (FKI) and gestation period (GP) were 412.02±9.91 days, 21.28±0.39 kg, 23.83±0.46 kg, 560±10 days, 296.01±7.15 days and 146.10±0.42 days, respectively. Females born as multiples took more time to attain puberty, thus more AFS and AFK. Goats with >18 kg body weight at kidding delivered higher weight per kidding and multiple births. Overall mean for 90 days and 140 days milk yield was 60.75±0.85 and 82.55±1.29 litres respectively with lactation length of 134.87±1.82 days.

Barbari male

Poultry

Improvement of germplasm

Rural poultry: The genetic and phenotypic response in 6-week shank length of PD-1 line was 2.53 and 1.05 mm per generation, respectively, over the last 11 generations. A total of 2,053 chicks of PD-6 (S-10) were produced using 44 sires and 250 dams, which were selected for higher shank length at 6 weeks. In PD-2 line (S-16), the body weight, egg weight, egg production and egg mass up to 72 weeks of age were 2,728 g, 55.8 g, 138.6 eggs and 7,898 g, respectively. The egg mass showed improvement of 451 g over previous generation. The S-17 generation was reproduced utilizing 50 sires and 250 dams, which were selected for higher egg mass up to 52 weeks. In PD-3 line (S-8), the egg production and egg mass up to 40 weeks of age increased considerably from the previous generation. The heritability estimates for production traits were low to high from sire and dam components of variance. The PD-3 line (S-9) was regenerated using 50 sires and 250 dams in a pedigreed mating. The body weight at 2, 4 and 6 weeks of age was 89.0, 202.8 and 341 g, respectively, in S-9 generation. The body weight improved from the last generation.

PD-1 cock

PD-6 cock

Evaluation of Janapriya, Vanaraja and Gramapriya

Janapriya, Vanaraja and Gramapriya varieties were evaluated under intensive system. Janapriya, a promising dual-purpose chicken variety developed by crossing PD-1 with PD-4, recorded body weight of 1,525 g at 12 weeks, while the annual egg production was 176.4 with egg weight of 60.5 g. The body weight at 14 weeks of age in Vanaraja and Gramapriya was 2,187 and 1,650 g, respectively. The annual egg production was 189 in Vanaraja and 240 in Gramapriya, which are higher than those recorded earlier.

Native chicken populations: Vanashree, evolved from Aseel (PD-4), is being improved for body weight in males and for egg production up to 40 weeks of age in females. Body weight at 40 weeks increased (by 93 g in cocks and 45 g in hens) in the present generation along with shank length in cocks (by 0.4 mm). Egg weights also increased (by 2.95 g at 40 weeks).

Aseel cock

In Ghagus, an indigenous chicken breed, hen housed egg production (117.8 eggs) improved by 10.84 eggs. The egg weight and body weight at 72 weeks were 52.7 and 2,288 g, respectively. An improvement of 87.6 g in body weight and 3.59 mm in shank length was recorded at 8 weeks in this generation.

In Nicobari chicken, improvement of 153 and 94 g in body weight and 1.6 and 1.58 mm in shank length were recorded in male and female birds, respectively. Hen day egg production (74.7) and egg mass (3,456 g) up to 40 weeks showed positive trend. The G-8 generation of Nicobari was produced (765 chicks).The heritability estimates of juvenile growth traits were moderate to high.

Nicobari chickens

In Kadaknath, body weight at 4 and 8 weeks was 124.4 and 403.7 g, respectively, which were higher than that in the previous generation. The age at sexual maturity was 176.2 days, while 40 weeks egg production was 76.3 eggs and egg weight was 45.8 g. The body weight of Aseel hens and cocks at 40 weeks was 1,942 and 3,246 g, respectively. The 40 weeks egg production (22.0 eggs) improved by 4 eggs in this generation.

Evaluation of Aseel crosses: Aseel crosses involving Aseel × PD-1, PD-6 or PB-2 were evaluated under intensive system in the farmers' field in Telangana. At 12 weeks of age, the Aseel cross with PD-1/PD-6 recorded body weight of 1,661 g, while the Aseel cross with PB-2 attained 2,249 g body weight at the same age.

Broiler populations: A total of 1,563 good chicks of PB-1 line (S-29) were hatched. Body weight at 4, 5 and 6 weeks was 582, 918 and 1162 g, respectively. Shank length at 5 weeks was 78.8 mm. Improvement in growth performance was observed compared to previous generation. To increase the variability in PB-1 line, a total of 1,467 chicks were hatched (S-0) from eggs brought from Bengaluru centre of AICRP on Poultry Breeding. The body weight at 5 and 6 weeks, and shank length at 5 weeks were 1102, 1404 g and 84.3 mm, respectively. The ASM, egg weight and egg production at 40 weeks, respectively were 171.7 days, 60.9 g and 59.8 eggs. PB-2 line of DPR (S-29) and Bengaluru centre (S-0) were evaluated. Body weight at 4 and 5 weeks were 670 and 951 g, respectively, while shank length and breast angle at 5 weeks were 80.2 mm and 80.7° in PB-2 line (S-0) of Bengaluru centre. Body weight at 5 weeks was 920 g in PB-2 line of DPR (S-29).The age of sexual maturity (ASM) was 184.5 days, which increased compared to the last generation. The 40 weeks egg production in Naked Neck and Dwarf gene lines (S-17) was 78.3 and 51.9 eggs, respectively.

Layer populations: Regeneration of the six-layer lines was completed. Three crosses, viz. Kadaknath × IWH, IWF × IWH and IWH × IWF were produced. The 16 weeks body weight increased in IWH, IWI and IWD lines, while it decreased in IWK and layer control compared to their respective previous generations. The ASM reduced significantly in IWH and IWD lines, whereas in other lines, it remained almost stable. The egg weight at 28 weeks increased in IWI and IWK lines, while it deceased in the IWH line. The egg production to 40 weeks showed significant increase in the IWI and IWD lines, while it decreased in IWF line compared to previous generation.

AICRP on Poultry Breeding

AICRP on Poultry Breeding completed 50 years of research successfully, marking the Golden Jubilee year of the project, in the year 2020.

At Mannuthy centre, the egg production of native chickens (S-5) up to 40 weeks was 79 eggs with egg weight of 43.9 g. At Anand centre, the 40 weeks egg production of Ankleshwar (S-2) was 76.38 eggs, while 72 weeks egg production in IWN and IWP strains (S-1)

was 307.2 and 317.5 eggs, respectively. Egg production of IWD and IWK strains (S-8) up to 64 weeks was 226.5 and 218.1 eggs, respectively. Bengaluru centre evaluated PB-1 (S-11) and PB-2 (S-25) lines. At Ludhiana centre, the body weight at 5 weeks was 1,150, 1,065 and 799 g in PB-1, PB-2 and native chickens, respectively. The body weight in Punjab Brown (native birds) at 4, 8, 20 and 40 weeks of age was 480, 696, 1,984 and 2,683 g, respectively.

At Jabalpur centre, Jabalpur colour females matured at 151 days and produced 161 eggs up to 52 weeks, while Kadaknath hens matured at 166 days and produced 93.7 eggs at the same age. Narmada nidhi hens produced 170 eggs up to 72 weeks in field with egg weight of 45.0 g. At Guwahati centre, the 52 weeks egg production of native chicken was 68.6 eggs with egg weight of 40.8 g. The egg production of Kamrupa variety up to 40 and 52 weeks was 49.9 and 91.3 eggs in the farm and corresponding values in the field were 44.3 and 74.8 eggs, respectively, whereas egg production in Daothigir variety up to 40 weeks was 18.1 eggs. At Palampur centre, egg production up to 40 and 52 weeks was 46.0 and 80.2 eggs, respectively in native chicken, whereas the corresponding values for Himasamridhi variety were 53.6 and 92.4 eggs, respectively.

At Ranchi centre, the egg production up to 72 weeks of native chickens was 91.5 (G-7) and the body weight at 4 weeks was 166.3 g. At Tripura centre, the 40 week-egg production of BND cross (E4) was 53.8 and 43.0 eggs under farm and field conditions, respectively. The body weight at 8, 20 and 40 weeks of age was 515.8, 1,605 and 1,964 g at farm and 435.2, 1,532 and 1,772 g, respectively, at farmers' field. During the year, 640,999 chicken germplasm was distributed to the farmers (4,127) from different centres.

Poultry Seed Project

The main objective of this project is local production of improved chicken germplasm and supply to various stakeholders in the remote areas to target production enhancement of egg and meat for augmenting rural poultry production, socio-economic condition of the target groups and linking small scale poultry producers with organized market. The project is in operation at 12 centres located across the country. A total of 419,477 improved chicken germplasm was distributed by different centres in their respective regions/states.

Improved crosses for rural poultry farming: CARI-Gracy and CARI-Nirsafed were developed to address issues of climate change for backyard poultry. These are dual type hardy efficient egg producers even in intense summer (hot and hot-humid) conditions and also good meat producers. This will help in increasing farmers' income by maximising production throughout the year.

***CARI-Gracy* (*Cross of Nicobari and CARI Red*):** Dual type coloured and a hardy bird suitable for tropical and subtropical climate. The production characteristics are age at sexual maturity, 170 days; 20-week body weight, 1,415 g; egg production (40 weeks), 85; egg weight (40 weeks), 48 g; egg production (72 weeks), 220–230; and egg weight (52 weeks), 52 g.

***CARI-Nirasafed* (*Naked neck 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. The production characteristics are age at sexual maturity, 155 days; 20-week body weight, 1502 g; egg production (40 weeks), 94; egg weight (40 weeks), 52 g; egg production (72 weeks), 220–230; and egg weight (52 weeks), 54 g.

Duck

Improvement of 100 g in 8 weeks body weight in S-1 generation compared to S-0 generation was observed. Egg production up to 40 weeks of age was more than 100 and was 182 up to 60 weeks of age. Heritability estimate of body weight (8 weeks) in S-1 generation of indigenous Kuzi ducklings was high in magnitude and those of conformation traits were moderate to high. Genetic correlations between body weights and conformation traits were positive and moderate to high in magnitude.

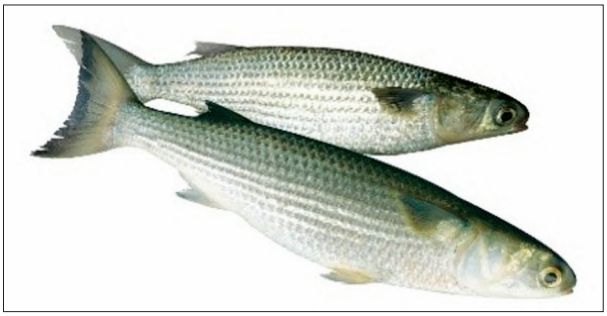
Fisheries

Breeding of fishes under controlled conditions

- Picnic seabream or black seabream (*Acanthopagrus berda*) is of aquaculture importance due to its high economic and recreational values, excellent meat quality and ability to tolerate wide variations in environmental parameters. Achieved its breeding and seed production by induced breeding using salmon GnRH-analogue hormone. The fishes spawned after 36 hr of inducement and the pelagic eggs hatched after 22 to 24 hr at a temperature of 28 to 30°C. Fecundity was 0.25 million per female (450 g) and 86% of the eggs hatched after 24 h. Larval rearing was carried out with various live feed organisms such as Copepods, Rotifers and *Artemia*. Metamorphosis of the larvae initiated in 24th day post-hatch (DPH) with 9% survival.

Picnic seabream or black seabream, *Acanthopagrus berda*

- Grey mullet (*Mugil cephalus*), a high-valued commercial brackishwater fish, was successfully bred under controlled captive conditions for the first time in the country. Captive maturation was achieved using sustained-release of LHRH and 17-MT hormone implants. Attained maturation percentage of over 80% in females with oocyte



Grey mullet, *Mugil cephalus*

diameter > 520 µm and in males with expressible milt. Larvae were reared in captivity with the survival of ~22% on a mixture of microalgae and other conventional live feeds. Hatchery-produced mullet seeds were given to progressive farmers for further rearing.

- Barred spiny eel, *Macrognathus pancalus*, is a bottom-dwelling economically important freshwater food fish. Brood fish with the average size of 16.65±2.47 cm and 23.36±5.43 g with gonado-somatic index ranging from 8.49 to 11.4 were successfully bred naturally under captivity in rectangular FRP tanks (2 m length × 0.35 m width × 0.5 m height) using water hyacinths as the substratum for egg attachment. The sticky eggs remained attached with the root hairs of water-hyacinth by their distinct stalk. Eggs were laid normally on the inner branches of the upper part of the roots of the water hyacinth that remain 2–3 inches below the water surface. Hatching occurred in 48–60 h. Yolk sac of the larvae got fully absorbed in 2 days after hatching. The larvae produced were reared with planktons, formulated feed and chopped tubifex worms. Small, cylindrical PVC pipes were used as refuges in the rearing tanks.

Spiny eel, *Macrognathus pancalus*

- Maskara barb (*Dawkinsia assimilis*) was successfully bred in captivity for the first time at RRC ICAR-CIFA, Bathinda. Fishes were procured from Bengaluru, Karnataka (9.5±0.5 cm/13±2 g) and reared in glass tank (200 L). On attaining maturity, males (avg. weight 18.5 g/avg. length 11.5 cm) and females (avg. weight 23.5 g and length 11.5 cm) were induced bred. The hatching percentage was 50–65%. Larvae attained the average size of 200 mg/21 mm after one month with 50% survival.
- Peninsular carp (*Labeo kontius*) is endemic to the Western Ghats and is recorded from the rivers Cauvery, Bhavani and Moyar and its tributaries in Karnataka, Tamil Nadu and Kerala. Earlier it was a valuable component of capture fisheries in the Cauvery river system, but its population has declined drastically in recent years. Pond cultured *L. kontius* attained the first maturity at one and half years of age and was successfully induced bred for the first time using salmon gonadotropin-releasing hormone (sGnRH) analogue and Domperidone in both males and females. Hatching of fertilized eggs occurred in 20–24 h of incubation and the hatched-out spawn were transparent, with conspicuous yolk mass and distinct head with transparent eyes. Yolk got completely absorbed and the larvae started feeding five days post-hatching.

Peninsular carp, *Labeo kontius*

- Three endemic fishes from the Western Ghats in Kerala, Malabar labeo (*Labeo dussumieri*), yellow catfish (*Horabagrus brachysoma*) and naadanmushi (*Clarias dussumieri*) were induced

Potential areas for seaweed farming along the Indian coast

India has enormous potential for seaweed mariculture; however, mass-scale commercial farming of seaweeds is yet to take off successfully in the country. R&D efforts over the years have resulted in techno-scientific improvements in farming technologies such as floating rafts, net-tubes, long-lines, and cage-based Integrated multi-trophic aquaculture (IMTA) systems for seaweed culture. In view of the emerging importance of seaweed mariculture, an all-India preliminary site selection survey suitable for seaweed farming was conducted by ICAR-CMFRI along all the maritime states of India. From this survey, a total of 23,970 ha area were identified in 317 locations as potential seaweed farming sites along the Indian coast. Details of the suitable sites and their demarcation on a preliminary spatial map will facilitate the imminent expansion and effective adoption of seaweed farming in the country.

Field validation of carp sperm cryopreservation technology

Technology on carp sperm cryopreservation was field-tested and successfully upscaled for use in improving hatchery seed quality and genetic exchange through field demonstrations for Tamil Nadu, Kerala, Bihar, Jharkhand, Madhya Pradesh, West Bengal and Haryana. During the year, 800 ml of milt from riverine stocks of Indian major carp was cryopreserved and stored in cryobank. Using cryopreserved milt, the genetically diversified seed was produced in selected hatcheries of Bihar, Haryana, Jharkhand, Kerala, Madhya Pradesh, Tamil Nadu and West Bengal. Approximately 40 lakh of spawn were produced at the selected hatcheries in the above states.

bred in hatchery conditions from wild-collected fishes raised to broodstock in pond conditions over a year. Spawn were reared in FRP tanks, fed with live feed and powdered artificial feed till they become the size, ready to distribute. A total of 3.5 lakh fry seed of *L. dussumieri* was provided to the farmers and Fisheries Department of Kerala.

Enhancement of fish production in floodplain wetland: Enhanced fish production was successfully demonstrated in the Kothia Maun of Bihar through necessary infrastructure which included 2 ha earthen-nursery pond, 0.8 ha CIFRI pen, six CIFRI GI cages, water-screen net at inlet and outlet of the wetland, 30 monofilament gill nets and one 12 ft OAL fibre boat. Altogether 8.726 tonnes fish seeds of catla, rohu, mrigal, grass carp, common carp and amur carp were stocked in the open wetland, nursery ponds, cages and pens, and training and skill development programmes were undertaken for 300 fishers. This activity brought awareness and perception change among the fishers regarding various aspects and techniques of fisheries management of floodplain wetland. Each year fish yield from stocked fishes under fisheries enhancement programme improved in a successive manner from 40.42 kg/ha/year in the first year (2018–19) to 111.11 kg/ha/year during 2020–2021, showing about a three-fold increase in productivity, thereby improving the socio-economic condition of the fishers.

Effluent management in inland saline aquaculture systems: Standardized biofloc-based technology for the rearing of Genetically-Improved Farmed Tilapia (GIFT) under zero-water discharge inland saline water at a carbon: nitrogen ratio of 15:1. Biofloc reactor was designed and fabricated for sludge processing from the biofloc units into microbial protein. Process optimization for the reactor required four days of sludge retention, intermittent aeration (12 h) and bioflocculating agent (30 ppm).

Effluent management in inland saline aquaculture systems

Application of biochar in inland saline aquaculture systems: Biochar application in sediment showed enhanced potassium ion and organic carbon (2.17 times) content of the sediment and improved the water quality by reducing ammonium ion concentration and enhancing Ca : Mg ratio in water. Application of potassium enriched sugarcane bagasse biochar in inland saline aquaculture systems at 0.5% level enhanced the K^+ in the *Penaeus vannamei* culture system from an initial value of 46 ppm to 96 ppm in 49 days of culture period. It also enhanced growth performance of Genetically-Improved Farmed Tilapia (GIFT).

❑

7. Crop Management

Crop Production

Effect of cutting schedules and rainfall pattern on *Cenchrus ciliaris*: For evaluating effect of rainfall pattern and cutting schedules on seed quality of *C. ciliaris* (var. IGFRI 3108) an experiment was conducted from 2018 to 2020 at Avikanagar station of ICAR–IGFRI. The year-wise findings revealed that average seed yield was comparable during 2018 and 2019 (82.8 and 81.4 kg/ha, respectively) but it was very low during 2020 (62.4 kg/ha). Among 3 years, proportion of filled spikelet was more adversely affected due to rainfall pattern during 2019 (26.8%) and least during 2018 (58.2%). Highest ergot formation was also recorded during 2019 (28.5%) and lowest during 2020 (13.9%). Mean germination of spikelet, after 6 months of storage, was observed from 10.4% (2019) to 20.8% (2018). The findings revealed that quantum of rainfall, number of rainy days and their distribution pattern during two weeks before and three weeks after 50% flowering play a crucial role in seed formation and/or fungal infestation (ergot formation) of spikelet. Cutting on 20 August for seed production was found better as compared to rest of cutting schedules as indicated by higher germination of 34.5 (2018) to 17.5% (2019). Higher seed and fodder yield were observed in no cut and the cutting on 20 July, but germination was reduced significantly as compared to cutting on 20 August.

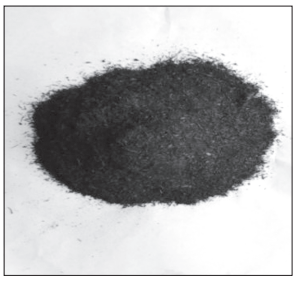
Drought mitigation strategies in tobacco: A set of drought management practices involving early planting with tray nursery seedlings, high density planting at 90 cm ×50 cm, starter application of calcium nitrate (CN) @ 25 kg/ha and foliar nutrition of N and K through potassium nitrate spray recorded highest productivity of cured leaf in the FCV tobacco grown in the drought prone areas of Karnataka light soils region of Karnataka. The yield increases of more than 11% was recorded.

Control

Starter nutrition with 25 kg CN/ha

Oil palm waste biochars as soil amendments: Application of oil palm waste biochars + 100% RDF significantly improved the cured leaf yield of FCV tobacco in light textured soils. Maximum soil available potassium was recorded in oil palm empty fruit bunch biochar amended soil.

Oil palm empty fruit bunches



Oil palm waste biochar

Development of biopolymers for enhancement of seed quality and as a carrier for agri-inputs: A polymer composition comprising a viscous cross-linked polymer solution, wherein the fungal spores can be entrapped, has been developed. The polymer composition can be used as a seed coating material and carrier matrix for entrapment of agri inputs which has high entrapment efficiency. The polymer composition showed good tensile strength, improved vigour index and uniform film coating. These polymer compositions were utilized for entrapment of beneficial microbes like *Trichoderma* which has exhibited 20–30% improvement in productivity. The *Trichoderma* has long shelf-life of 24 months, a better release profile due to barrier properties of polymer matrices and seed germination of studied crops.

Doubling farmers' income through Integrated Farming Systems using low-cost interventions: A total of 8 Integrated Farming Systems suitable for 4 States namely Andhra Pradesh, Bihar, Chhattisgarh and Haryana have been refined through farmers participatory approach with low-cost interventions like diversification through high yielding varieties, balanced nutrient application, improved weed management practices, diversification with high value crops, introduction of goatary, poultry,

Liquid retting accelerator 'CRIJAF SONA' for faster jute retting

An endospores-based liquid formulation of CRIJAF SONA was developed for jute retting that has 3 times longer shelf-life (18 months) than its talc-based counterpart and is more resistant to environmental stress. In comparison to 30 kg talc-based formulation/ha, it only requires about 1,000 ml for one ha of jute retting. Jute retting can be completed within 12 days, with a 2-grade improvement in fibre quality over conventional retting. The use of a liquid formulation also lowers the cost of fibre production. The resulting jute fibre has a better fibre strength ranging from 23.6 to 27.7 g/tex.

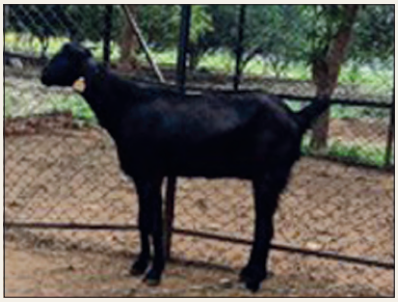
Farmer participatory refined farming system components in Kanker district of Chhattisgarh

ICAR-Central Institute of Cotton Research (CICR) IFS Model for enhancing farm income

Rainfed monocropping systems have low yield and lead to low income. Crop diversification is a choice available to increase productivity as well as farm income. Therefore, an Integrated Farming System (IFS) model was developed at ICAR-CICR for rainfed cotton-based system for central India. Firstly, a diagnostic survey was done to identify farmers' choice, resource availability, demand in the local market and compatible enterprises. The results of the IFS model (2017–21) showed that pigeonpea intercropped in cotton (6:2 ratio) in one-acre recorded seed-cotton yield of 823 kg and pigeonpea grain yield of 152 kg. In another one-acre area, soybean was cultivated in *kharif*, followed by chickpea + mustard during the *rabi* season. Soybean produced 864 kg grain yield, while, in *rabi* 1,060 kg chickpea and 75 kg mustard were harvested. The remaining area (0.5 acre) was allocated to goatery, vegetables, fruits, water-harvesting pond and fodder unit. Goatary (Usmanabadi) unit of size 9+1 could earn a net return of ₹ 15,812 with an employment generation of 120 man-days. A poultry (Giriraja) unit with 100 birds in two batches, realized a net profit of ₹ 65,614 over the year. The horticulture component in IFS yielded a net profit of ₹ 29,134. This component included fruits (custard apple, papaya) and vegetables (French bean, bhindi, tomato, gourd group vegetable). Overall, one-ha IFS model produced 70.2 q/ha cotton-equivalent yield with a B:C ratio of 1.95. In one year, 3,020 kg feed, 1,590 kg fodder, and 2.50 tonnes manure were produced in the system and were used as input for different enterprises. Water harvested in 20×20 m^2 pond was used for life-saving irrigation in *rabi* and vegetable crops. The ICAR-CICR IFS model for 1 ha, could generate 492 man-days during the one-year cropping season.

Fruits

Napier grass



Goatary

Water harvesting structure

Vermicompost

Poultry

Vegetable

Crops

Forestry

Farmer participatory refinement of Integrated Farming Systems in selected districts

State	District (No. of farm households involved)	Refined farming systems	Mean area (ha)	Bench mark net income (₹/year)	Cost of intervention (₹)	Net income (₹/year) after intervention (Mean of 4 years)
Andhra Pradesh	Vizianagaram (8)	Field crops + horticulture + dairy + poultry	0.56	35,430	8,515	70,588
		Field crops + dairy + poultry	0.64	40,880	8,515	87,757
Bihar	Purnea (3)	Crop + dairy + fishery	0.65	50,900	4,142	1,38,395
		Crop + dairy	1.50	43,915	4,744	99,697
Chhattisgarh	Kanker (3)	Crop + dairy + goat + poultry	0.96	53,799	29,895	1,87,121
		Crop + dairy + piggery + poultry	1.70	62,680	13,250	1,35,025
		Crop + dairy + poultry	0.90	70,000	15,760	2,18,080
Haryana	Sirsa (1)	Crop + dairy	0.50	39,744	15,175	2,08,294

Pusa Decomposer— A microbial consortium for *in situ* paddy straw management

Pusa Decomposer is a microbial consortium of fungi developed by IARI for accelerated degradation of paddy straw into manure in 20–25 days. This technology is an effective eco-friendly solution for agri-residue management and an alternative to burning, thereby decreasing air pollution and improving soil health. A standard operating protocol (SOP) has also been developed for *in situ* management of agri-residue. The protocol involves application of the Pusa Decomposer spray, followed by rotavator for proper mixing of the spray with the straw and light irrigation to ensure moisture in the field. During 2020, Pusa Decomposer was demonstrated in an area of about 13,420 ha in different states of the country including Delhi. In 2021, the Pusa Decomposer shall be applied to > 15 lakh acres in the four states of Punjab, Haryana, Uttar Pradesh and Delhi.

Pusa Decomposer | Spraying | Mixing and incorporation | Irrigation | Germination of wheat

FarmTree: An Android Platform-based Mobile App for Agroforesters

ICAR-Central Agroforestry Research Institute, Jhansi has developed an android platform-based application named 'FarmTree' (https://play.google.com/store/apps/details?id=com.cafri.farmtree as well as on CAFRI's website: http://www.cafri.res.in/) on the package of practices of 25 promising agroforestry tree species of India, viz. teak (*Tectona grandis*), bamboo (Bamboo species), sandal (*Santalum album*), red sandal (*Pterocarpus santalinus*), mahogany (*Swietenia mahogany*), shisham (*Dalbergia sissoo*), *Ailanthus excelsa*, siris (*Albizia lebbek*), babool (*Acacia* sp.), subabool (*Leucaena leucocephala*), neem (*Azadirachta indica*), mahaneem (*Melia dubia*), anjan (*Hardwickia binata*), bhimal (*Grewia optiva*), gamhar (*Gmelina arborea*), simal (*Bombax ceiba*), karanj (*Pongamia pinnata*), kadamb (*Anthocephalus cadamba*), poplar (*Populus deltoides*), mangium (*Acacia mangium*), casuarina (*Casuarina equisetifolia*), khejri (*Prosopis cineraria*), eucalyptus (*Eucalyptus tereticornis*), arjun (*Terminalia arjuna*), and gliricidia (*Gliricidia sepium*). This application provides a user-friendly, bilingual (Hindi and English) e-platform to have necessary and crisp information on important agro-forestry tree species to the farmers. It covers various aspects like general descriptions, potential areas, silvicultural requirements, nursery techniques, planting techniques, tending operations, suitable agroforestry systems, tree protection, yield, utilization and material availability of each tree species along with few success stories.

fodder, mineral mixture supplementation, de-worming, artificial insemination, small-scale processing and capacity building.

Crop Protection

Emerging insect pest tea mosquito bug in cotton: During last two years incidence of tea mosquito bug was observed in cotton crop and it causes heavy damage to cotton crop. Taking into consideration the importance of this pest, damage potential was assessed. The molecular identification confirms the species as *Helopeltis theivora*. Severely damaged shoots die back due to the effect of bug saliva and causes a bunched terminal growth known as 'witches broom'. The boll infested by this pest develops characteristic black wart eruptions. A single 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* could make as many as 63, 80, 71, 59, 51, 96 and 56 feeding punctures in 24 h, respectively. Cotton leaf area damaged by an individual per day for 1st instar, 2nd instar, 3rd instar, 4th instar, 5th instar nymph and female and male adult of *H. theivora* were 25, 62, 119, 173, 186, 229, 526 mm^2, respectively.

Papaya ring-spot virus (PRSV) infecting jute plant: Leaves from jute (*Corchorus olitorius*) plants showing virus like symptoms, viz. downward curling, puckering, angular brownish to yellowish spots were used for high throughput sequencing (HTS). Total RNA was extracted from each leaf which was subjected to construction of cDNA libraries. Sequencing was done on Illumina Hiseq 4000 (CytoScan, Thermo Fisher). Approximately 46 million 105 nt paired end reads were generated. Raw reads were trimmed and filtered to perform *de novo* assembly. The obtained contig was 10,326 bp nucleotides (nt) long and in BLASTn against GenBank showed highest identity with papaya ring spot virus (PRSV) with the contig covering 99.6% of the viral genome. The obtained contig shared 99.33% sequence similarity with PRSV strain P (Accession No. MT470188). To confirm PRSV infection, reverse transcriptase polymerase chain reaction (RT-PCR) was conducted by using isolated RNA. One pair of PRSV specific primer (PSRV1F: 5' TTAAATCTGATTC-GTC 3' PRSV 1R: 5' GAAATTCACGCAAAG-TCGA3') was developed by using primer BLAST software and was used in RT-PCR assays. Amplified fragments were cloned and sequenced and all the fragments shared 98% sequence identity with PRSV. One of the amplicons sequence was deposited in NCBI (Accession No. MN615832).

Jute plant infected with papaya ring- spot virus (PRSV)

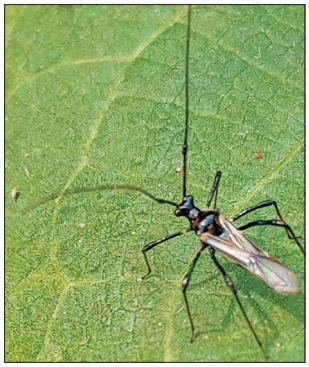
Incidence and spread of an alien invasive pest cassava mealybug (CMB): A highly destructive alien invasive cassava mealybug, *Phenacoccus manihoti*, was first reported on cassava in Thrissur, Kerala during April 2020. Later it was reported from other parts of Kerala and Tamil Nadu. Extensive damage to cassava was recorded from Kayamkulam and Thrissur in Kerala; Namakkal and Salem in Tamil Nadu to a tune of 86%. The alternate host plants of CMB were found to be *Alternanthera sessilis*, *Synedrella nodiflora* and *Blumea lacera*.

Besides, cassava cultivars, viz. Mulluvadi, Thailand White, Sree Athulya and Sree Vijaya were severely infested with damage ranging from 7–86.7%. Infested plants showed symptoms such as drying of leaves, distortion of the stem, clumping of leaves, shortening of internodes, bunchy tops and total debilitation of the plant. The identity of CMB was further confirmed with molecular tool, COI and the sequences conformed with *P. manihoti* accession from China (MT895817). In the absence of effective native natural enemies and other methods of its control in India, the prospects of its suppression by classical biological control are quite vibrant. ICAR and ICAR–NBAIR have taken up persistent initiatives to import the parasitoid, *Anagyrus lopezi* from CGIAR-International Institute of Tropical Agriculture (IITA), Republic of Benin (West Africa). With due acknowledgements to CGIAR-IITA the parasitoids have been received at ICAR-NBAIR, Bengaluru, India. As per the standard protocols of quarantine studies on the biology, safety and host specificity of the *A. lopezi* were completed till F_3 generation to ensure its non-target impacts. Further, a

Witches broom symptom

Bolls affected by TMB

Adult TMB female

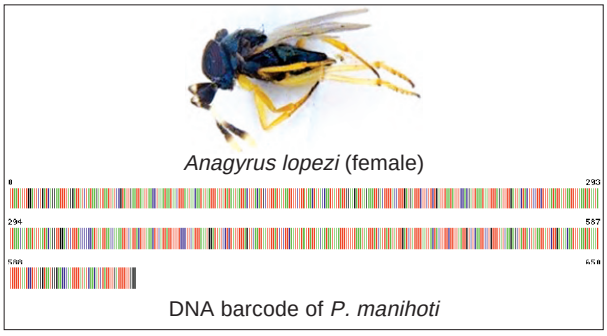


Adult TMB male

Life stages of *P. manihoti*

CMB infested field in Tamil Nadu

request has been made to DPPQS for limited area release of the parasitoids in cassava plantations in Tamil Nadu and Kerala.

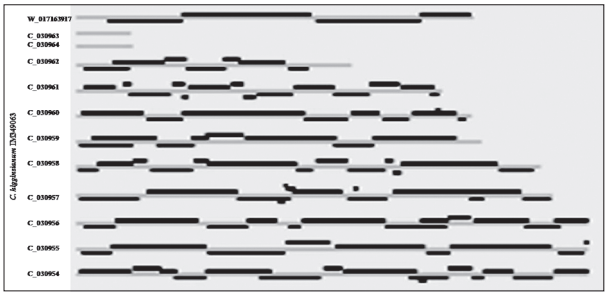


Anagyrus lopezi (female)

DNA barcode of *P. manihoti*

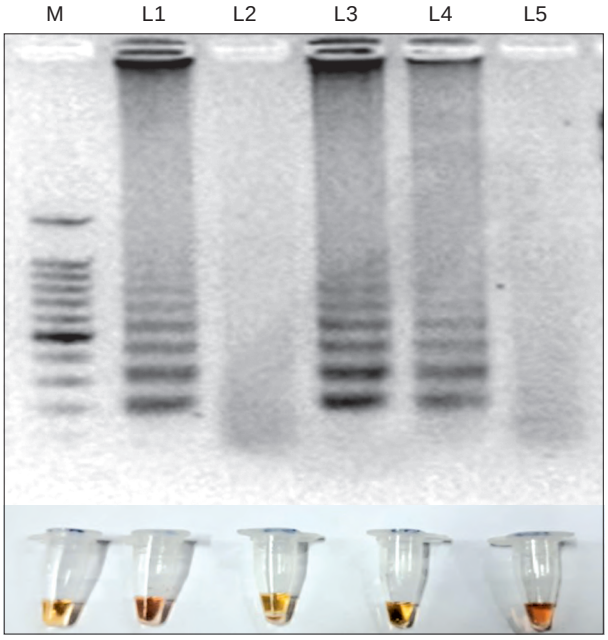
Enhancing efficacy of *Trichoderma*-based sugarcane management system: Application of the three most promising *Trichoderma* isolates (STr-64, STr-83 and STr-126) alone or in combination with different fertilizer doses resulted in an increase in germination by 7.0 to 17.6% over FYM application alone. There was no significant effect of various treatments on sugarcane girth, brix and Pol (%). However, there was significant variation in cane length, yield and NMC among the different treatments. Overall, the effect of *Trichoderma* on sugarcane yield was more pronounced under low nutrition conditions. The application of *Trichoderma* isolates STr-83 and STr-126 without inorganic fertilizer application resulted in 24.5 and 22.1% increase in yield over control, respectively. Similarly, application of these two isolates along with 50% RDF also showed a 17–18% increase in yield over 50% RDF application alone. However, *Trichoderma* application along with 100% RDF did not result in further yield increase compared to 100% RDF alone. Based on the results, two promising *Trichoderma* isolates, viz. STr-83 (*T. longibrachiatum*) and STr-126 (*T. harzianum*) were identified with the potential to enhance sugarcane yield by 17–24.5% especially under conditions of low inorganic fertilizer usage.

Genome sequencing of red-rot pathogen of sugarcane: Whole genome sequence of virulent pathotype (*Cf*08) of *C. falcatum* causing red rot in sugarcane revealed, 617 CAZymes and of these glycoside hydrolases were predominant (298). Among 7,264 genes associated with pathogenicity/virulence, 77 genes having effector functions were identified. The assembled genome showed its similarity with the genome of *C. graminicola* and *C. higginsianum*, the causal organisms of anthracnose in maize and in members of *Brassicaceae*, respectively. A total of 94 large sequences (>100 Kb) of *Cf*08 were mapped over *C. Higginsianum* 10 of 12 chromosomes with 106 synteny blocks.



Mapping of 94 sequences from *C. falcatum* (*Cf*08) over *C. higginsianum* (10 of 12 chromosomes) with 106 synteny blocks, depicting co-linearity between *C. falcatum* and *C. higginsianum.*

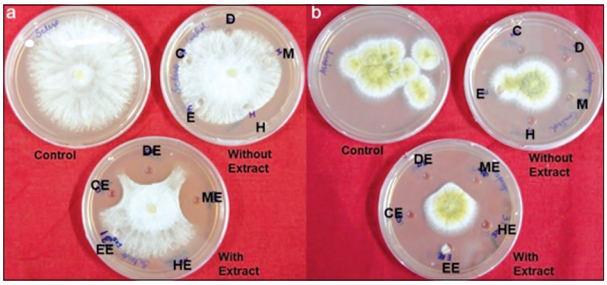
A rapid, sensitive LAMP-based assay for ecological monitoring of *R. solani* AG-1 IA: A colorimetric LAMP assay was developed using polygalacturonase gene which yielded visual confirmation of the *Rhizoctonia solani* AG-1 IA causing sheath blight. Development of yellow colour in the reaction mixture indicated presence of *R. solani* AG-1 IA. Sensitivity of the LAMP assay was as low as 1.65 fg/µl of template DNA and could effectively detect the pathogen from diseased plant tissues and soil samples. The LAMP assay was highly specific for *R. solani* as it did not show any amplification with fungal and bacterial out-groups like *R. solani* AG-1 IB, *R. solani* AG 2- 2IIIB, *R. solani* AG-3, *R. solani* AG-7, *R. solani* AG-8, *Colletotrichum capsici*, *Sclerotium rolfsii, Sclerotinia sclerotiorum*, *Trichoderma asperellum, Fusarium oxyporum*, *Curvularia prasadii, Cochiliobolus tuberculatus*, *Alternaria alternata*, *Colletotrichum*



L1, *R. solani*; L2, Healthy plant; L3, Infected plant; L4, Metagenome; L5, NTC
LAMP-based detection of *Rhizoctonia solani* AG-1 IA.

capsici, Ustilaginoidia virens, Sarocladium oryzae, Curvularia oryzae, Curvularia lunata, Mangaporthe oryzae, Rhizoctonia oryzae-sativae, Bacillus subtilis and *Pseudomonas plecoglossicida,* respectively. This study will help in designing an effective point of care diagnostic method for early monitoring of *R. solani* and thereby planning timely preventive measures against the pathogen.

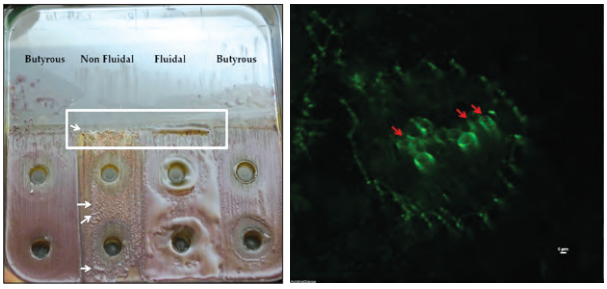
***Streptomyces amritsarensis* V31—a potential bioagent for control of phytopathogenic fungi:** *Streptomyces amritsarensis* V31 showed high antifungal activity against a wide range of fungal pathogens including *Alternaria alternata, Aspergillus flavus, Fusarium oxysporum* f. sp. *lycopersici, Sarocladium oryzae, Sclerotinia sclerotiorum,* and *Rhizoctonia solani*. Metabolite extracted from *S. amritsarensis* V31 in different solvents inhibited these pathogens to different extent. Solvent extracts of *S. amritsarensis* V31 significantly reduced the incidence of rice-sheath blight both as preventive and curative sprays. Chemical profiling of the metabolites in DMSO extract of *S. amritsarensis* V31 revealed 6-amino-5-nitro-



Antifungal activity of metabolites extracted from *Streptomyces amritsarensis* strain V31 against different fungal pathogens; *A. flavus* (a), *A. alternata* (b), *F. oxysporum* f. sp. EA, ethyl acetate; MeOH, methanol and DMSO, dimethyl sulfoxide.

sopyrimidine-2,4-diol as the predominant compound present. It was evident from the LC-MS analyses that *S. amritsarensis* V31 produce a mixture of potential antifungal compounds which could inhibit the growth of different phytopathogenic fungi. The results of this study indicated that metabolite extracts of *S. amritsarensis* V31 can be exploited as a bio-fungicide to control phytopathogenic fungi.

A simplified protocol for reversing phenotypic conversion of *Ralstonia solanacearum*: *Ralstonia solanacearum* have the problem of losing the virulence in laboratory conditions during prolonged biocontrol experimentation by a phenomenon termed as phenotypic conversion (PC). Since pure colonies of *R. solanacearum* contains cell fractions differing in virulence, it was considered worthwhile to find a way of selecting the cells with lower attenuation. Initial screening indicated inductive effects of *Phyllanthus emblica* on pure colonies. Along with *P. emblica* extract, it was also found that nutrient deprivation could also selectively activate virulent-type fractions from pure colonies of PC strains. *P. emblica* extract suppressed *R. solanacearum* initially in well diffusion, but further developed virulent type colonies around the wells. Nutrient deprivation was created pouring slanting medium and found to have synergistic effects with *P. emblica* extract. The converted fluidal (virulent type) colonies could colonize vascular bundles and cause wilting symptoms. Live–dead cell



Protocol for induction of virulence colony types in *R. solanacearum* using full-strength KMTTC medium. (*left*) Induction of the fluidal colony by Indian gooseberry extract and slanting plate for induced nutrient deprivation in *R. solanacearum*: left to right sequence = NAIMCC-B-01630 (butyrous), NAIMCC-B-01630 (non-fluidal), NAIMCC-B-01630 (fluidal), and TB-01838 (butyrous), (*right*) Confocal scanning laser microscope images showing colonization of *gfp* tagged *R. solanacearum* NAIMCC-B-01630 in tomato vascular bundle in 488 nm channel; scale bar=5 µm.

imaging using *Bac*Light, effects of ascorbic acid on cell viability, and production of virulence factors (exopolysaccharides, cellulase, and pectinase) supported this hypothesis. The methodology for enhancing virulence of *Ralstonia solanacearum* was further confirmed by *in-planta* establishment of converted virulent colonies by *gfp* tagging and expression. The pathogen was able to establish fastidious nature and signals of *gfp* was observed from xylem vessels through confocal scanning laser microscopy. Studies on PC are not only significant for maintaining virulent colony types for laboratory studies, but also for the stability of avirulent

strain applied for cross-protection. The methodology was also found to be useful in maintaining virulence in old culture (> 4 years) indicating wider utility.

Leaf spot of maize caused by *Curvularia geniculata* reported in India: For the first time leaf spot was observed on maize cv. Kanchan during a survey of the Ballia district in Uttar Pradesh, India, with disease severity ranging from 1 to 20%. The upper mid canopy of symptomatic plant showed elliptical light brown spots (0.25 to 2.5 mm diameter) surrounded by chlorotic halo lesions with dark margins. Based on morphology, the fungus was tentatively identified as *Curvularia geniculata*. Molecular characterization of isolate E29 showed 99 to 100% similarity with sequences of *C. geniculata*. The similarity index for ITS, gpd, LSU, and D1 and D2 region of LSU sequences of E29 showed high similarity with isolates of *C. geniculata:* 99.81% with MH856584 (CBS187.50), 99.52% with KM083609 (CBS187.50), 100% with MH868092 (CBS187.50), and 100% with MH868533 (CBS220.52), respectively. Pathogenicity of the isolate E29 was confirmed by inoculating 25 days old maize cv. Kanchan (n = 10) with a spore suspension (10^6 spores/ml) prepared from 15 days old cultures. After 10 days, elliptical spots with chlorotic halo were observed on inoculated plants similar to those observed in the field, but no symptoms developed on noninoculated plants. The disease appears not to be yield limiting and anecdotal evidence suggests that maize hybrids may differ in susceptibility. To our knowledge, this is the first report of leaf spot of maize caused by *C. geniculata* in India, which extends the known agents of maize-leaf spot.

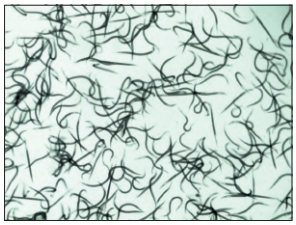
Improved extraction protocol of neem azadirachtinoids: Novel bench-scale knowhow of green process of extraction of azadirachtin concentrate from neem-seed kernel (NSK) (32 to 38% purity) has been developed. The process of its protection under patent is being pursued. This accomplishment holds significance from commercial angle as currently industry has process for extraction of 20% purity and one with higher purity available in industry has to use hazardous solvents. The quantification of azadirachtinoids was carried out using UPLC-QTOF-ESI-MS which showed separation of Aza-A, B and H in UPLC with respective characteristic molecular ion peaks. Further ultrasonic assisted extraction method was optimized to sequentially separate maximum content of neem oil and azadirachtinoids using response surface methodology (RSM). Major meliacins present in neem oil were characterized as nimbin, desacetylnimbin, salannin and desacetylsalannin. Sequential extraction method developed for extraction of neem oil and azadirachtinoids will prove helpful for neem oil and biopesticide industry in better utilization of NSK as a valuable resource.

Microbial formulations for biofortification of wheat grains with Fe and Zn: A detailed study was carried out to isolate and identify efficient bacterial endophytes for wheat to further enhance the genetic potential of low accumulating wheat genotype for uptake and translocation of iron and zinc in plant parts and grains. Plant microbe interaction studies conducted in deficient soils and using genotypes identified as low accumulator for zinc or iron revealed that isolates DS-178 and DS-179 were more potent for zinc acquisition, whereas endophytes DS-68 and DS-163 were efficient for iron acquisition in grains. All the four endophytes showed IAA production, siderophore production, phosphorus solubilisation and ammonia production ability. On the basis of 16S rRNA gene sequencing these four endophytes were identified as *Bacillus subtilis* DS-178 and *Arthrobacter* sp. DS-179; *Arthrobacter sulfonivorans* DS-68 and *Enterococcus hirae* DS-163. In general, the amount of Fe and Zn in grains due to inoculation of endophytes was 2 folds higher as compared to un-inoculated control. TEM studies revealed that the endodermis, cortical region, root-hair extension, xylem and xylem vessels, pericycle and vascular bundles were more pronounced and thicker in inoculated treatments as compared to control. The organic acid profile showed five types of organic acids in root exudates with citric acid being the predominant acid produced. The amount of total organic acids was 5-fold and 8-fold higher due to inoculation of *Arthrobacter sulfonivorans* and *Arthrobacter* sp., respectively, as compared to control. The concentration of citric acid, succinic acid and acetic acid increased many folds in root exudates of inoculated treatments. Four *TaZIP* genes were targeted for expression studies using gene specific primers and expression was achieved only for *TaZIP3* and *TaZIP7* genes in wheat genotype 4HPYT-414. The results clearly indicated endophyte mediated over expression of these two genes in roots and shoots. Zinc solubilizing (*Bacillus subtilis* DS-178 and *Arthrobacter* sp. DS-179) and siderophore producing (*A. sulfonivorans* DS-68 and *E. hirae*) endophytes were also evaluated under field conditions for biofortification of wheat grains with Fe and Zn. Endophytes inoculation significantly increased the fresh weight and dry weight of root and shoot, yield and yield component (number of grains/m^2, number of grains/spike and seed weight of 1,000 grains). Inoculation of siderophore producing endophytes *A. sulfonivorans* and DS-68 *E. hirae* DS-163 increased the iron concentration in wheat grains from 30 to 49 mg/kg. Endophytes *B. subtilis* DS-178 and *Arthrobacter* sp. DS-179 efficient for Zn solubilisation could increase the Zn concentration in wheat grains from 28 to 42 mg/kg.

Commercialization of the technology 'Dynamic volatile collection system' (Patent appl. No. 1235/DEL/2015)

This system samples organic volatile compounds under natural environment condition by continuous air-flow, thus avoiding suffocation and volatile saturation. Sampling and analysis of volatiles would aid identification of their exact composition which has tremendous applications in perfumery, food technology, pest and disease monitoring, pheromone technology, pest management etc. This technology has been transferred to a private company for commercialization.

EPN biopesticide formulation technology: A novel ICAR-SBI entomopathogenic nematodes (EPN) biopesticide formulation was developed first of its kind in a unique combination of carrier materials to attain a longer shelf-life with viable infective nematode juveniles (IJs) of EPN by providing adequate aeration and moisture. The formulation containing *Heterorhabditis indica* strain SBITND78 has a shelf-life of nine months with 92% survival of nematodes and the formulation containing *Steinernema glaseri* strain SBILN1 has a shelf-life of 12 months with 90% survival of nematodes. Successful control (more than 75%) of white grub under field conditions obtained with ICAR-SBI EPN biopesticide formulation. The ICAR-SBI EPN biopesticide formulation technology has been commercialized to six biopesticide companies with a license fee of 2 lakhs per licensee.



Infective juveniles of *Heterorhabditis indica* strain SBITND78

Biological control of aquatic weed *Salvinia molesta* in Madhya Pradesh

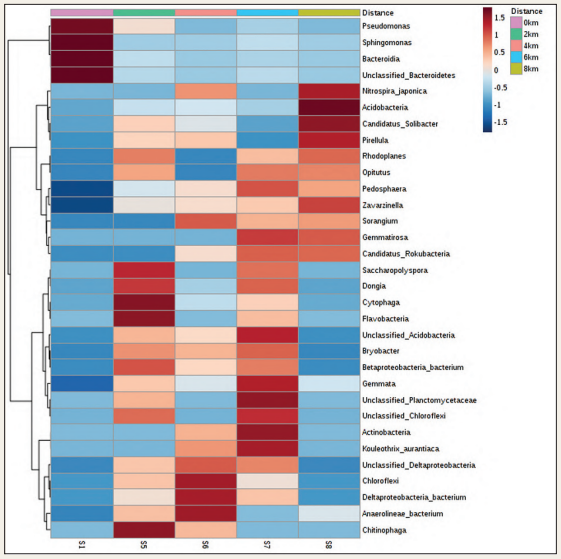
Salvinia molesta, commonly called as water fern is becoming an aggressive aquatic weed in Central and North India. Adult weevils of host specific bioagent *Cyrtobagous saliviniae,* were released in 20 ha *Salvinia*-infested pond in Padua village of district Katni in Madhya Pradesh. Complete control of the weed was achieved within six months and there was no regeneration of weed thereafter.

Releasing of bio-agent in December 2019

Complete control after 18 months

Identification of key biological indicators of pesticide contamination

Comparative whole metagenome sequencing was performed to estimate variations in the bacterial OTU's and its populations between the lindane contaminated and non-contaminated soil samples. There was significant change in the Shannon diversity index across the sampling sites depicting variation in the microbial composition as influenced by the pesticide contamination. It was found that at the lindance contaminated site there was significant loss in the representation of members of phyla *Acidobacteria*, *Actinobacteria*, *Gemmatimonadetes* and *Ignavibacteriae*. The Linear discriminate analysis showed that *Marinimicrobium* was the significantly affected genera due to lindane contamination. The heat map depicts that at the lindane contaminated site there was high abundance of PAH degrading genera like *Pseudomonas, Sphingomonas*, *Bacteriodia,* etc.



Topramezone a new herbicide for board leaf weed control in chickpea: Chickpea is severely infested with broadleaved weeds during *rabi* season and no post-emergence herbicide is available to control broadleaved weeds. Topramezone, a promising herbicide, is found to be effective to control broadleaved weeds and some of the narrow leaved weeds. Topramezone applied @ 20.16 g/ha at 20 days after sowing is found to be very effective in controlling broadleaved weeds.

Weed-wiper technology for managing weedy rice: Weedy rice can reduce rice yields by 40–70%. In Kerala, its infestation in Kuttanad, Kole and Palakkad area is forcing the farmers to even abandon rice cultivation. There are no selective herbicides for its effective control. AICRP-Weed Management centre at Thrissur, developed a weed-wiper device for selective drying of weedy rice earheads by application of glufosinate ammonium at 10–15% in standing rice crop.

HORTICULTURE

Crop Production

Fruit crops

Customized micronutrient mixture for Nagpur mandarin: On the basis of survey and soil and leaf analysis of 18,000 ha citrus growing orchards of Vidarbha region of Maharashtra, a customized micronutrient mixture containing iron, manganese, zinc and boron was prepared and field validated for benefit of citrus growers.

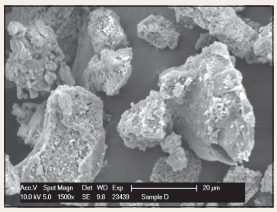
Technology for cultivation of papaya under net-house: Cultivation of papaya under net house has been developed for obtaining additional yield of 100 kg in Co. 8 variety and 40 kg in Red Lady variety of papaya and without incidence of papaya ring spot virus (PRSV).

Technology for cultivation of papaya

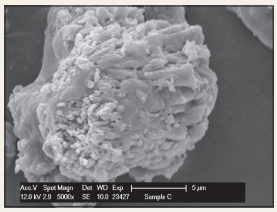
High-density planting in litchi: In a high-density planting system in litchi, enhanced yield of fruits (17.28 tonnes/ha) under 6 m×4 m (400 plants/ha) planting was recorded.

Biocompatible nanoclay-polymer composites and nanoparticles for grapes

Clay-polymer composites (CPCs) using starch, guar-gum, chitosan as polymer and clay, sugarcane bagasse and grape pomace as filler were synthesized. Particle size anlaysis of polymer composites (clay, clay + pomace) and nanoparticles was confirmed and observed to be less than 100 nm. Percent iron loading was maximum (5.3%) in guar-gum grafted composite having pomace as a filler with Fe-EDTA, whereas zinc loading was also maximum (6.25%) in guar-gum grafted composite when clay and pomace were used as filler with Zn-EDTA. Clay-polymer composites and nanoparticles as a fertilizer carrier will help in increasing micronutrient use efficiency especially in case of Fe and Zn having low availability in calcareous soils.



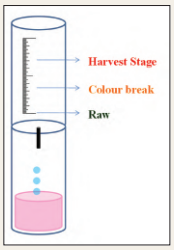
SEM micrographs of chitosan grafted CPC loaded with zinc and iron



SEM micrographs of starch grafted CPC loaded with zinc and iron

Development of a 'Litchi Maturity Kit' for judging optimum time of harvest

A 'Litchi Maturity Kit', that provides an easy and handy option to accurately judge acidity of litchi fruit was developed. The kit is based on the established principle of neutralization of acids with a base (NaOH) using phenolphthalein as indicator. A reliable indicator of optimum fruit maturity is the attainment of 18–20°B TSS and acidity of less than 0.5%.



Diagrammatic representation of 'Litchi Maturity Kit'

Canopy management in ber: An improved 'Y' shaped training system with significantly more fruit yield (23 tonnes/ha) in four year old orchards of ber varieties (Gola, Thai, Goma Kirti and Thar Sevika) has been standardized.

Multiplication of clonal rootstocks of apple: Technology for production of clonal rootstocks of apple by hardwood stem cuttings using soilless growing medium was standardized. It comprised 30 cm cutting along and treatments (Cocopeat 75: vermiculite 25) under greenhouse conditions with cent per cent rooting.

Plantation crops

Nutrient mixtures for coconut: Two formulations on nutrient mixture, viz. Kalpa Poshak and Kalpa Vardhini were developed for the enhancement of growth of juvenile palms and improving the productivity of adult palms, respectively. About 37% enhancement in nut yield was observed in the palms treated with Kalpa Vardhini @ 500 g/year in two splits.

Integration of napier grass in coconut-based cropping: About 75% more fodder yield (Co 5 hybrid napier) was realized in coconut-based farming system with a productivity of 210 tonnes/ha through application of nutrients 90:30:24 NPK, recycling of organic inputs such as cow-dung slurry (3,750 litre/ha), vermicompost (2 tonnes/ha) after every cutting (6 times a year) in two equal splits at fortnightly intervals along with *Azospirillum* (3.5 kg/ha).

Impact of tender nut harvesting on growth, productivity and energy efficiency: The impact of tender nut harvesting on growth and production of coconut palm was studied in red sandy loam soil. Harvesting of tender nut throughout the year recorded significantly more yield (187 tender nuts/palm) with 14 number of bunches/palm. Harvesting of mature nuts throughout the year showed reduced yield (97 mature nuts/palm) with 12 bunches/palm. The observations revealed that continuous harvest (at 210±7 days after inflorescence emergence) of nuts for tender nut water is ideal for increased nut yield.

Further, 2.47% increased input energy had been converted to 72.8% increase in output energy due to tender nut harvesting throughout the year as compared

Different stages of rooting of cutting of apple in soilless rooting medium under protected conditions

to harvesting only mature nuts highlighting the superiority of the practice. This is further supported by the significantly more net energy (77.1%), energy use efficiency (68.6%), energy productivity (68.6%) and energy profitability (72.8%) with tender nut harvesting over mature nut harvesting.

Integration of honeybees in coconut plantations: A record yield of 198 nuts/palm/year could be obtained from ecological engineering with Kalpa Sankara hybrids realizing more than ₹1.5 lakh from 39 palms. About 7.1% increase in nut yield was observed after the installation of honey bee colonies.

Vegetable crops

Micronutrient management in vegetables: Foliar application (1 g/l) of crop group specific micronutrient formulations three times at 10 days intervals after 30 days of planting enhanced the yield of French bean cv. Kashi Sampann by 13.8 to 20.8% over non-sprayed control.

Organic production of vegetables: The maximum green leaf yield of coriander (9.83 tonnes/ha) and root yield of radish (43.2 tonnes/ha) with net return ₹81,652 and B:C ratio of 1.78 was obtained with application of 20 tonnes/ha FYM + 100:60:60 kg NPK/ha + IIHR microbial consortium @ 12.5 kg/ha + plant protection through organic methods. Hence, the above organic package was recommended for production of radish and coriander in Agro-climatic Zone-IV.

Similarly, three years observation at Dharwad revealed that application of FYM @ 20 tonnes/ha + NPK @ 80:60:80 kg/ha + PP chemicals + IIHR microbial consortium @ 12.5 kg/ha produced the maximum yields in coriander-radish sequence with a B:C ratio of 2.88. Hence, the above organic package has been recommended for Agro-climatic Zone-VIII.

Three years study in Nagaland on organic production of spinach beet revealed that application of vermicompost 5 tonnes/ha + PSB + *Azospirillum* (each 5 kg/ha) registered maximum leaf yield (172.83 q/ha) which was *at par* to application of FYM 20 tonnes/ha + PSB + *Azospirillum* (each 5 kg/ha). However, maximum net

Vegetable specific liquid nutrient formulation 'Arka Sasya Poshak Ras'

The liquid nutrient formulation (comprising solutions A and B) is a unique balanced blend of the macro (N, P, K, Ca, Mg and S) and micronutrients (Fe, Mn, Cu, Zn, B and Mo). This formulation is suitable for commonly grown vegetables—tomato, chilli, cabbage, zucchini, cucumber, ridge gourd, French bean, peas, cowpea, dolichos bean, etc. and leafy vegetables such as, amaranth, coriander, palak, etc. It is highly suited for cocopeat based cultivation and balcony, terrace gardening, in open or polyhouse conditions.

return (₹ 2,04,595) and B:C ratio (1:4.35) was recorded with application of FYM 20 tonnes/ha + PSB + *Azospirillum* (each 5 kg/ha). Hence, application of FYM 20 tonnes/ha + PSB + *Azospirillum* (each 5 kg/ha) was recommended for organic production of spinach beet (Palak) in Agro-climatic zone III (NEH region).

Vegetable based organic farming system: Under organic farming, maximum productivity in terms of wheat-equivalent yield (291.98 q/ha) and net return (₹2,82,324/ha) was recorded in cowpea-cauliflower-bottle gourd sequence. Application of FYM @ 25 tonnes/ha increased the organic carbon content of soil by 31.7% over inorganic cultivation with recommended dose of fertilizer. The maximum microbial activity in soil was observed under application of NADEP compost @ 25 tonnes/ha.

Integrated weed management in vegetables: Three years study on weed management in okra at Vellanikkara revealed that pre-emergence application of pendimethalin @ 6 ml/l + one hand weeding at 25 days after sowing was suitable for maximum fruit yield of 143.58 q/ha with the B:C ratio of 2.1. Hence this was recommended for weed management in okra in the tropical sub-humid lateritic soils of Agro-climatic Zone VIII.

Pre-emergence application of pendimethalin @ 6 ml/l along with one hand weeding gave maximum yield of okra (144.94 q/ha) with B:C ratio of 2.13 in okra cv. Arka Anamika under Nagaland condition.

Seed production technology of vegetables: In pumpkin cv. Arka Suryamukhi, physiological maturity of seed was attained due to harvesting of fruits at 45 days after anthesis. The 10 days of pre-storage period before seed extraction resulted in maximum seed yield and quality under Bengaluru conditions. These seeds also retained their viability and vigour even after 12 months of storage under ambient conditions.

Spraying with mixture of ferrous sulphate @ 0.2%, calcium nitrate @ 0.2% and boron @ 0.1% gave maximum seed yield (1.07 q/ha) with highest B:C ratio (2.63) in chilli var. LCA 620 at Lam, Andhra Pradesh, whereas it had maximum seed productivity in chilli var. Azad Mirch 1 (1.23 q/ha) at Kanpur with maximum B:C ratio (2.35). Similarly, at Jabalpur also maximum (2.8 q/ha) seed yield of chilli var. Pusa Jwala was recorded due to this treatment. Hence, it was recommended for Lam (zone-VI), Kanpur (zone-IV) and Jabalpur (zone-VII) conditions.

Integrated phosphorus management in acidic soils: Observations in acidic soils of Udhagamandalam hills, Tamil Nadu revealed that rock-phosphate can substitute the application of single super phosphate (SSP) in potato when applied in combination with the phosphate solubilizing bacteria (*Bacillus megaterium)*. Significantly maximum yield (22.72 tonnes/ha) of potato varieties such as Kufri Swarna and Kufri Sahyadri was recorded with single super phosphate which is *at par* with 100% P supplied as rock-phosphate + PSB (20.12 tonnes/ha). Thus, rock-phosphate + PSB could be used as an effective alternative source for phosphorus in acidic soils under peninsular India.

Weed management in taro: Mulching with plastic ground cover mats was found effective for weed management in taro resulting in 95–98% weed-control efficiency and maximum cormel yield (22–30% increase over hand weeding) based on the preliminary findings.

Nutrient requirement of swamp taro: Nutrient requirement of swamp taro was worked out to be 15 tonnes of FYM and 120-60-90 kg/ha of N, P_2O_5 and K_2O to produce optimum growth and yield of stolons in Assam, Tripura, West Bengal and Kerala, based on preliminary data.

Dairy waste compost as a potting medium in black pepper: A method has been developed to produce dairy waste compost (leftover paddy straw, fodder grass and weeds in dairy unit) using *jeevamruthum*, enriched rock-phosphate and poultry manure as nutrient sources. Analysis revealed that enriched compost contained significant amount of nitrogen (0.61%), phosphorus (1.59%), potassium (0.35%), calcium (2%) and magnesium (0.33%) within 60 days of fermentation period.

By using this compost as one of the ingredients in potting mixture for the production of rooted cuttings, 88 cuttings could be harvested per mother plant/year in black pepper. Thus, dairy waste compost can be used as an alternative medium to normal potting mixture for the production of healthy rooted black pepper cuttings.

Artificial technology for production of guchchhi mushroom: For the first time, production of guchchhi mushroom (*Morchella*) under semi natural conditions was successful in greenhouse. As a result, India has entered the list of few countries like USA, China and France culturing guchchhi mushroom under artificial conditions.

Morchella cultivation under artificial conditions

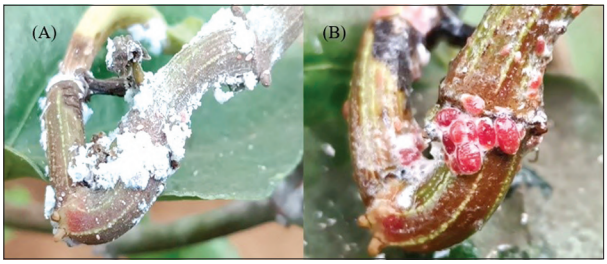
Crop Protection

Insect pests management

Management of stem-borer in grapes: Integrated management schedule for stem-borer (*Dervishiya cadambae*) in grapes comprising removal of loose bark from main

trunk and cordons during July–August and washing (2 ml/l water) them with *Metarhizium brunneum* (5×10^8 spores/ml) (@ 1.5 to 2 litre formulation/plant) was standardized.

Arka Mealymelt—Mealybug exterior body wax dissolving formulation: Mealybugs (Hemiptera: Pseudococcidae) are small, sucking polyphagous plant pests which feed on various horticultural crops. Since mealy bugs are covered with thick-wax coating, it is difficult to manage these insects through chemical control alone, besides requiring multiple applications of insecticides for their management. A proprietary product formulation, 'Arka Mealymelt' has been prepared which dissolves the wax coating, thus making them vulnerable. This product has been evaluated and found effective on different species of mealy bugs in a range of horticultural crops.



(A) Before and (B) after application of Arka Mealymelt

Arka Cucurlure

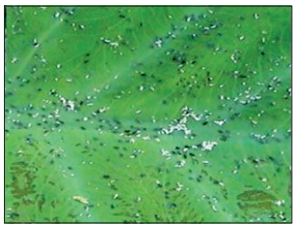
A novel kairomone blend for effective trapping of male melon flies, *Zeugodacus cucurbitae* was standardized. The technology is based on combinative plant volatiles from cucurbitaceous fruits and cue lure. The lure attracts a larger number of males (~50%), over the conventional cue lure trap.

Management of sucking pests in okra: In search of new alternatives to neonicotinoid insecticides against sucking insect pests of okra, Flupyridifurone 200 SL @ 2.5 ml/l was observed most promising with lowest whiteflies (4.38/3 leaves), leafhoppers (4.86/3 leaves) and gave maximum fruit yield (10.94 tonnes/ha) and maximum B:C ratio of 1:3.22 under Raipur condition.

Pest management in okra through organic sources: To promote organic pest management in okra, seed treatment with *Bacillus pumilus* 1% A.S (10 ml/kg seed) and application of 20 tonnes of FYM enriched with *B. pumilus* (5 litre/ha) recorded the maximum decrease in *M. incognita* population (67.57%) accompanied by highest yield (30.83% over control) with B:C ratio (1:1.93). It was at par with seed treatment with *P. putida* 1% A.S @ 10 ml/kg seed and application of 20 tonnes of FYM enriched with *P. putida* (5 litre/ha) in reducing the final nematode population (66.51%) and increasing the yield (29.44% over control) and B:C ratio (1:1.91) under Bengaluru conditions.

Eco-friendly pest management in cabbage: To identify the eco-friendly and green pest management options, application of neem seed powder extract (40 g/l) and Diafenthuron 50 WP (1 g/l) consistently resulted in significant reduction of aphid population over control and provided significantly more yield (193.35 q/ha and 200 q/ha, respectively) in cabbage. These two treatments were recommended for the management of cabbage pests specially cabbage aphids during *rabi* in mid hilly zone conditions of Himachal Pradesh.

Management of sucking pests in taro (*Colocassia*): Sucking pests of taro, viz. aphids and whitefly could be controlled by insecticidal treatments with Imidacloprid 17.8 SL (0.5 ml/l) or Thiamethoxam 25 WG (0.5 g/l). The technology was recommended for Assam, Tripura, Bihar and Telangana.



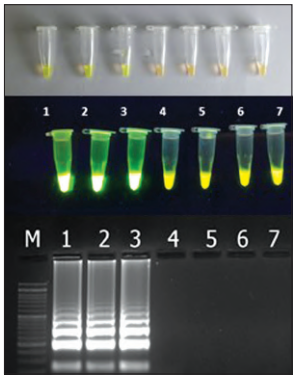
Resistance against sweet potato weevil: The intensity of feeding by sweet potato weevil on the tubers of the sweet potato plants and different *Ipomoea* sp. (*I. palmata, I. triloba, I. mauritiana* and *I. obscura*) was studied by choice assay test against weevil. Among different *Ipomoea* sp., sweet potato weevil infestation was not observed in *I. mauritiana* and *I. palmata*.

Aphids and thrips management in coriander: The maximum per cent reduction in aphid (94.38%) and thrips population (94.88%) was recorded on coriander plants treated with IPM module (seed treatment with imidacloprid 600FS @ 3 ml/kg seed + foliar spray of ker plant extract @ 10 ml/litre + *Verticillium lecani* (1×10^8 cfu/g) @ 6 g/litre + fipronil 5% SC @ 0.035%).

Similarly, thiamethoxam 0.025% + Synergist 5% proved most effective (>90%) in reducing the aphids population in fenugreek, coriander and cumin crops and was superior to the commercial formulation of thiamethoxam.

Disease management

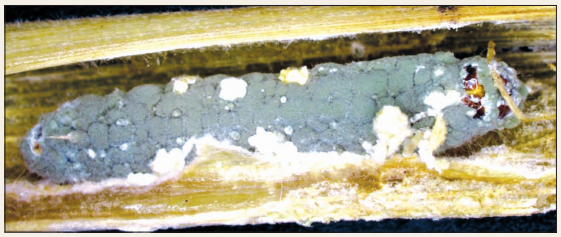
Molecular marker for specific detection of *Fusarium oxysporum* f. sp. *cubense* subtropical race 4 (STR4): By *in silico* analysis, three specific set of primers were designed



Development of Loop mediated isothermal amplification assay for rapid and sensitive detection of *Foc* STR4

First report of an isolate of fungus, *Metarhizium pingshaense* infecting *Conogethes punctiferalis*

An entomopathogenic fungus, *Metarhizium pingshaense* was isolated from an infected larva of *Conogethes punctiferalis* (Crambidae: Lepidoptera), a highly polyphagous pest. Bioassay studies of the fungus showed that it is very virulent to *C. punctiferalis*, causing more than 86% mortality to fifth instar larvae at 1×10^8 spores/ml. The median lethal concentration (LC_{50}) of the fungus against late instar larvae was 9.1×10^5 conidia/ml and the median survival time (MST) of late instar larvae tested at the doses of 1×10^8 and 1×10^7 conidia/ml were 4.7 and 6.4 days, respectively. The optimal temperature for fungal growth and sporulation was observed to be 25±1°C. This is the first report of *M. pingshaense* naturally infecting *C. punctiferalis*. Isolation of a highly virulent strain of this fungus holds promise towards development of a potential myco-insecticide against this pest.



Sporulating cadaver of *Conogethes punctiferalis* infected by *Metarhizium pingshaense*

and among these, *Foc* STR41/*Foc* STR42 set specific marker allowed target amplification of 248 bp in the characterized highly virulent STR4 *Foc* isolates but did not show any product amplification in other races (Race 1 and TR4).Thus, the markers developed in this study are novel and potentially useful for early detection and monitoring of virulent strains of *Foc* STR4.

Bio-intensive management of powdery mildew in grape: Application of chitosan @ 2 ml/ha in combination with *Ampelomyces quisqualis* (5 g/l) resulted in efficient management of powdery mildew as well as resulted in residue compliant quality grapes.

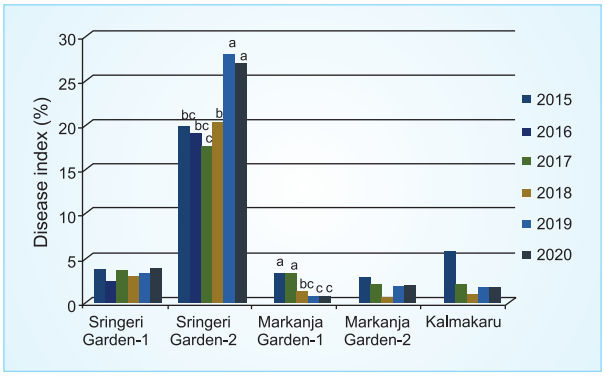
Management of bacterial blight: Foliar applications of Mancozeb 75 WDG (2.5 g/l) at the onset of the bacterial blight preceded with three sprays of *Bacillus subtilis* (2 g/l) gave the best control of bacterial blight in grapes.

Characterization of pathogen associated with lethal wilt disease of coconut: The pathogen associated with lethal wilt disease of coconut prevalent in Thanjavur, Thiruvarur and Pudukottai districts of Tamil Nadu was characterized by multilocus sequencing as '*Candidatus* Phytoplasmaasteris'-related strain belonging to 16SrI group.

Identification of substrate for entomopathogenic fungus: Wheat bran was observed to be the ideal substrate for the mass multiplication of the *Simplicillium lanosoniveum*, a potential entomopathogenic fungus on rugose spiralling whitefly, *Aleurodicus rugioperculatus*. Eggs, nymphs and puparia of the exotic rugose spiralling whitefly, *A. rugioperculatus* were highly infected by *S. lanosoniveum* (@ 1×10^8 spores/ml) under laboratory bioassay.

Effect of mulching on yellow leaf disease in arecanut: Plastic mulching during monsoon (June–October) along with nutrient management based on soil test results reduced the disease index by 34.5–78.8% during 2017–2020 in gardens with low initial disease index (2.9–5.8%). However, the disease index was more (26.8%) with plastic mulching in the gardens with more initial disease index (19.8%). Thus, plastic mulching is useful in combating the yellow leaf disease when initial disease index is low.

Plastic mulching in YLD affected arecanut garden



Disease Index in plastic mulched plants

Integrated management of fungal diseases in tomato: For management of fungal diseases in tomato, a biological module has been standardized which is effective and economical. It comprises of seed treatment by talc-based formulation of *Trichoderma* sp. (BATF-43-1) @ 1%, nursery soil application (25 g/m^2) of talc-based *Trichoderma* sp. (BATF-43-1), seedling root dip in slurry (10 g + 100 g vermicompost + 250 ml water) of BATF-43-1, drenching (1%) by BATF-43-1, thrice at 25 days interval started 25 DAT. It resulted no root rot and wilt disease in the field while minimum early blight severity on foliage (65.41%), *Phytophthora* rotted fruits were 66.4% out of total diseased fruits, maximum marketable yield (459.64 q/ha) with B:C ratio of 1: 1.76.

Management of nursery diseases in vegetables using new fungicides: Drenching of Fenamidone + Mancozeb @ 0.25% in the nursery has been standardized and recommended in chilli variety G 4 and LCA 334 and tomato variety Arka Vikas.

Integrated management of vector borne virus diseases of chilli: For integrated management of vector borne virus diseases of chilli (at Lam, Bhubaneswar, Hessaraghatta, Parbhani and Coimbatore), application of neem cake (1 kg/m^2) in the seed bed, seed treatment (8 g/kg seed) with imidacloprid, spraying (1.8 ml/l) of cyazpyr at two to three days before transplanting, seedling dip (0.5 ml/l) with imidacloprid and growing of two rows

Diagnosis of Tomato Leaf Curl Bangalore Virus (ToLCBV)

The Arka Viral Kit is based on Loop-mediated Isothermal Amplification (LAMP) to diagnose Tomato Leaf Curl Bangalore Virus (ToLCBV). It is superior in specificity, sensitivity, and rapidity to other molecular techniques like PCR, RT-PCR, and real-time PCR. It is user friendly, as the testing can be done in a water bath or dry bath; and cost-effective compared to other PCR based diagnostic kits.

of maize/sorghum as border crop in the main field along with sliver agrimulch sheet + rotational spray of insecticides (Acephate @ 1.5 g/l + neem oil @ 2.0 ml/l) + (Fipronil @ 1 ml/l + neem oil @ 2 ml/l) + (Imidacloprid @ 2 g/15 l + neem oil @ 2.0 ml/l) + (Cyzpyr @ 1.8 ml/l) at 7 days interval till fruit formation has been recommended. Residual analysis of pesticides indicated that the acephate @ 1.5 g/l, fipronil @ 1 ml/l, imidacloprid @ 2 g/15 litre and cyzpyr @ 1.8 ml/l were not detected in HPLC/GLC testing. The B:C ratio varied from 1:3.1 to 1:1.9.

IDM package for tomato diseases: At Coimbatore, Parbhani and Hessaraghatta, integrated management module comprising covering of nursery with 40–60 mesh white nylon net until transplanting, border crop with maize in main field, nursery treatment (application of Seed Pro bio-formulation) of (i) Seed priming @ 4 g/kg, (ii) soil application @ 10 g/kg of soil while potting, and (iii) soil drenching @ 5% after seed germination) and main field treatment [Seedling dip with 0.1% (Carbendazim 12% + Mancozeb 63% WP) + spray with Acephate 75% WP @ 1.5 g/l on 10 days after transplanting + spray with Fipronil 5% SC @ 1.5 ml/l on 20 DAT+ spray with copper hydroxide 77% WP (2.0 g/l) on 25 DAT + spray with imidacloprid 70% WG @ 2 g/15 l on 40 DAT + spray with Fenamidone 10% + Mancozeb 50% WDG (0.25%)] two to three times from 45 DAT at 10 days intervals was observed most effective in the management of tomato diseases (damping off, early blight, late blight, bud necrosis and leaf-curl disease) and maximum fruit yield. Pesticide residue analysis for this treatment revealed that pesticides were not detected. The B : C ratio varied from 1:2.5 to 1:10.3.

Bio-intensive management of diseases of capsicum under protected cultivation: At Solan, treatment combination consisting of the use of seed pro @ 10 g/kg seed for seed treatment and application of soil solarization to soil bed followed by incorporation of 5 kg FYM fortified with 500 g neem cake and 50 g *Trichoderma* sp.+ 50 g *Paecilomyces lilacinus* at the time of bed preparation when combined with periodic spray and drenching of Phyton @ 4 ml/l, three times at 15 days interval beginning from 30 days after transplanting proved most effective in limiting all diseases like collar rot/root rot, powdery mildew and YLCV. Fruit yield of coloured capsicum was 663.95 q/ha and B:C ratio 9.99.

IDM packages for cucurbit diseases: At Lam (Ridge gourd cv. Local), Junagadh (Bottle gourd cv. Pusa Naveen), Parbhani (Cucumber cv. Pune Khira) and Sabour integrated management practice module involving growing of two rows of maize as border crops and use of agri-silver mulch sheet followed by seed treatment with carbendazim 12% + mancozeb 63% @ 3 g/kg and drenching of captan 70% + hexaconazole 5% WP @ 0.1% 15 days after germination followed by spraying of tebuconazole 50% + trifloxystrobin 25% @ 1 g/l + spray with (imidacloprid 17.8 SL @ 7.5 ml/15 l + neem oil 0.2%) followed by fosetyl-Al @ 0.1% at 10 days interval was highly effective in reducing severity of damping off, *Alternaria* leaf blight, *Cercospora* leaf spot, downy mildew and mosaic diseases. Pesticide residue analysis for this treatment revealed that no pesticide was detected. The B:C ratio ranged between 1:1.3 to 1:17.9.

Integrated disease management in bitter gourd: At Vellanikkara, Kerala for the integrated management of diseases of bitter gourd, seed treatment with Carbendazim 12% + Mancozeb 63% @ 3 g/kg and drenching with Captan 70% + Hexaconazole 5% WP @ 0.1% at 1st true leaf emergence stage after germination, followed by 5–6 spraying of Seed Pro (1%) at 10 days interval in rotation with neem oil (0.2%) alternatively after 15 days after drenching with a B:C ratio of 1.78:1 has been standardized.

Management of late blight of potato: Spray schedule of mancozeb 75% @ 0.2% (before the appearance of disease) followed by azoxystrobin 11.5% + mancozeb 30% WP @ 0.25% (at the onset of disease) and one more spray of azoxystrobin 11.5% + mancozeb 30% WP @ 0.25% (after 7 days of second spray) has been recommended.

Diagnosis of viruses in potato: A protocol to extract high-quality RNA from polysaccharide-rich tissues of potato tuber, i.e. sprouts and periderm was standardized by slightly modifying the protocol by addition of high salt buffer. The modified protocol can be utilized for RT-LAMP based detection of PSTVd directly from the tubers.

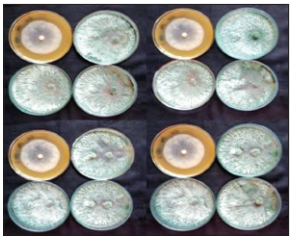
One step reverse transcriptase-recombinase polymerase amplification (RPA) assays were developed for accurate detection of potato virus X and potato virus S in potato leaves as well as in potato tubers. Comparison of sensitivity of detection revealed that RT-RPA could detect the PVX up to 10^{-5} dilution of the total RNA while

PCR could detect the virus up to 10^{-3} dilution indicating that RPA is 100 times more sensitive than PCR. RPA was further simplified using crude extract as template which could detect the virus up to 10^{-4} dilution.

Studies on the effect of Acquisition Access Period (AAP) and Inoculation Access Period (IAP) on transmission of ToLCNDV-potato by *Bemisia tabaci* (Asia II5) revealed that at least 30 min period for acquisition access and inoculation access are needed to transmit the virus.

Management of taro leaf blight disease: Mancozeb + Metalaxyl M 0.1% or Copper hydroxide 0.2% were found effective in minimising the taro leaf blight disease incidence at Kalyani, Jorhat, Ranchi, Dapoli, Jagdalpur, Palampur, Dholi, Rajendranagar, Coimbatore and Port Blair centres based on preliminary trials.

Characterization of biocontrol agents effective against fungal pathogens: Four *Trichoderma asperellum* isolates, effective against all major fungal pathogens of tropical tuber crops, viz. *Sclerotium rolfsii*, *Phytophthora colocasiae*, *Colletotrichum gloeosporioides* and *Fusarium* spp were identified. A cassava tuber based simple procedure was standardized for the multiplication of these isolates. The multiplication procedure ensures a population >10^{20} cfu/g substrate with all isolates.



Trichoderma asperellum isolates

Multiplication of *Trichoderma asperellum* isolates on cassava tubers

Endophytes as biocontrol agents: The potential endophytes *Bacillus amyloliquefacience* from root of *Phyllanthus niruri* and *Bacillus licheniformis* from the leaf of *Aloe vera* against *Colletotrichum gloeosporioides* causing anthracnose in greater yam have significant contributions on growth promotion activities in test plants, cowpea. The combination of seed treatment and spraying was more effective. Based on pot trial evaluation, *B. licheniformis* was selected for field trial evaluation against greater yam anthracnose. Minimum disease intensity was in combined treatment (Soil treatment + Spraying treatment) of *Bacillus licheniformis.*

BL Seed treatment + spraying | *Bacillus lincheniformis* | Seed treatment

Growth promotion by *Bacillus licheniformis*

Diagnostic kit (DsMV ELISA KIT) against *Dasheen mosaic virus*

A diagnostic kit (DsMV ELISA KIT) against *Dasheen mosaic virus* developed from the DsMV polyclonal antibody obtained after immunization of two New Zealand white rabbits against Dasheen mosaic virus protein (DsMV-IgG) and validated with more than 250 elephant foot yam leaf samples from different locations.

Management of leaf spot (*Colletotrichum capsici*) and leaf blotch (*Taphrina maculans*) in turmeric: It comprises of rhizome treatment with propiconazole (0.1%) and foliar spray of propiconazole (0.1%) which significantly mitigated the leaf spot and leaf blotch diseases. Further, the presence of fungicide residue was below the detectable limit (BDL) in the turmeric rhizomes.

Management of coriander powdery mildew (*Erysiphe polygoni*): The foliar spray of propiconazole (0.1%) at the initiation of the disease and second at 15 days after first spray mitigated the powdery-mildew disease (5.22 PDI) as against the control (86.37 PDI) with fungicide residue below the detectable limit.

Management of stem gall in coriander: It comprised of foliar spray @ 219.75 g a.i./ha at 45, 60 and 75 days after sowing with a mix formulation of azoxystrobin (11% SC) + tebuconazole (18.3% SC) and recorded maximum incremental benefit cost ratio (IBCR) of 1:2.91 with 63.52% decrease in stem gall disease of coriander and 45.74% yield increase over control.

Ginger rhizomes primed with *Trichoderma asperellum*

A novel process for priming rhizomes and tubers using *Trichoderma* spp. standardized

A novel process to improve the vigour of buds and to provide uniform tillering by priming seed rhizomes and tubers with the biocontrol fungi, *Trichoderma* spp. was developed. The priming helped to regulate the germination process, prevents the growth of dry rot pathogens during storage and also provides protection from fungal pathogens during the initial stages of the crop.

Effect of *Bacillus safensis* on growth of turmeric. *B. safensis* inoculated (*Left*) and control (*Right*)

Multi trait PGPR, *Bacillus safensis* for mineral solubilization and biocontrol traits: *Bacillus safensis*, a PGPR, exhibited significant suppression of the soft-rot pathogen, *Pythium* spp. and foliar pathogens infecting ginger and turmeric. Evaluation trials showed that the *B. safensis* can convert the non-available forms of phosphates and zinc to its soluble form, thus increasing the availability of phosphorus and zinc thereby improving the plant growth and increase the crop yield. Application of reduced levels of Zn and P along with *B. safensis* was observed to improve the physico-chemical parameters of soil, viz. organic carbon, available nitrogen etc. and microbial parameters like microbial biomass C, N and dehydrogenase enzyme activity in soil.

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8. Livestock Management

Nutrition

Cattle

Improving nutrient bioavailability: Feeding of maize grain sprouts with straw bedding to crossbred dairy cows during early-to-mid-lactation in addition to the existing feeding practice increased milk yield and milk fat and SNF.

Herbal feed supplementation in Frieswal bulls significantly increased the semen quality parameters, viz. volume (4.63 to 5.59 ml), sperm motility (46.3 to 53.9%), total sperm concentration (4,607 to 6,210 million) and motile sperm concentration (2,150 to 3,134 million).

Developed 'SIReDAM' an online data entry software for real-time data entry under the AICRP on Cattle program.

Sheep

Nutritional modules for commercial broiler sheep production were developed. Cost wise, feeding of milk replacer for 8 weeks to be economical due to savings on the cost of milk replacer for 4 weeks, besides saving of labour associated with the preparation, feeding and cleaning involved in milk replacer feeding to lambs.

It was evident that the dietary supplementation of rumen protected long chain fatty acids (LCFAs, 3–5% of DMI) enhanced the G-protein coupled receptor 40 (GPR40) of free fatty in the various segments of gastrointestinal tract of sheep. The chemosensing of LCFAs by GPR40 activated the signaling transduction pathways and increased the secretion of gut peptides particularly cholecystokinin that facilitated the fat digestion and absorption.

Pig

Feed: Economic yet nutritionally balanced vegetable waste/fruit waste based silages significantly improved feed conversion ratio and net protein utilization in crossbred grower pigs. Feed cost per kg gain was reduced by ₹9.00 at 10% supplementation of vegetable silage by replacing the whole concentrate. Similarly, feeding of the silage made of banana stem and maize fodder improved the growth performance in large White Yorkshire pigs.

Poultry

Microbiome: Microbiome of poultry, viz. Nicobari, Ghagus and Aseel, and a commercial broiler were studied. The amplicon sequencing results emphasized more similarity of the microbiota within the gut lumen of indigenous breeds as compared to the broiler strain. Further, existence of breed or line specific core microbial as well as across breed or line core microbiome was observed, besides the occurrence of beneficial and potentially opportunistic pathogenic microbes as part of the core microbiome.

Zinc supplement: The Zn content of eggs could be increased by 20.7 to 28.9% in layer chicken by supplementing inorganic Zn and by 27.1 to 31% by organic Zn at 40 to 160 ppm of supplementation. Zinc oxide nano particles could be synthesized using moringa and neem leaf extract with average particle size of 10.84 and 8.27 nm, respectively.

Alternatives to antibiotic growth promoter: Mannon oligosaccharide (MOS) (500 g/tonne) alone or in combination with two other prebiotics, i.e. fructose oligosaccharide (FOS) and galactose oligosaccharide (GOS) (330, 40 and 165 g/tonne, respectively) in antibiotic growth promoter (AGP)-free broiler diet yielded performance similar to that of AGP-fed broiler chicken. Feed conversion efficiency improved when GOS alone was fed @ 250 g/tonne. Furthermore, probiotic strains [*B. amyloliquifaciencs*, BA (100 g/tonne) and *B. coagulans* and *B. pumilus* in combination (100 g/tonne)] improved FCR, which was similar to the AGP-fed control group. Significantly improved performance, ready-to-cook yield and breast meat yield, and reduced *Salmonella* count in the gut were observed in broilers with bacteriophage supplementation in drinking water (0.02 ml/bird) on alternate days. Evaluation of prevalence of antimicrobial resistance genes in chicken gut samples (96) of broiler chickens collected from market indicated

Low cost poultry incubator from recycled waste (Waste to Wealth)

Under 'waste to wealth' programme, low cost incubator (portable egg hatcher) were developed utilizing the scrap produced in the form of discarded consumer durables such as refrigerators. The incubator, which can accommodate around 500 eggs, is suitable for the resource poor farmers involved in backyard poultry/ rural poultry farming. Beside, discarded refrigerators, other required components can be easily sourced to fabricate these low cost incubators suitable for rural poultry farming on DIY (Do It Yourself) basis. The main feature of this technology is that it does not require complex technical knowhow and costs just around ₹ 5,000–6,000/unit. This technology allows egg setting and hatching activities simultaneously in single cabinet with overall hatchability of 85%. There is a provision for running on DC/AC supply with minimum power of 300 Watts. Inverter/battery/solar panel power source is sufficient to run the equipment during power shortages/failures. This technology would help the resource poor farmers to have their own hatchery making them self-reliant in chick production.

presence of AMR genes for beta lactamase and fluoroquinolone resistance.

Broiler feed: Higher levels of GH and steroid hormones facilitated the rapid growth rate in post hatch broiler chicken. *In vivo* GnRH treated birds consumed less feed and gained more body weight of 1.89 kg at day-30 as against 1.41 kg in control birds with FCR of 1.60 and 1.71, respectively.

Nutrigenomic studies: Supplementing yeast-enriched selenium in diet differentially influenced plasma and magnum amino acid concentration in Vanaraja and Aseel hens. Similarly, Se supplementation affected the expression of amino acid transporters in jejunum and magnum differentially among the Vanaraja and Aseel hens. The ghrelin and melatonin receptors gene expression in jejunum of Vanaraja hens was downregulated, whereas in Aseel it was upregulated.

Microbial bio-therapeutic supplement: *Lactobacillus plantarum* and its metabolites were used as probiotic/ postbiotic to improve the gut health of chickens. The probiotics were collected at 24 and 48 h of incubation. The postbiotics of both periods of incubation were characterized for the physical attributes, *in vitro* free radical scavenging activity against DPPH and ABST+, *in vitro* antimicrobial activity and *in vitro* anti-inflammatory potential. There was a linear decrease in pH of the media with period of incubation (24 vs. 48 hr). The osmolarity of the broth increased with duration of incubation (0.046, 0.048 and 0.051 mOs/L). The postbiotics obtained from *Lactobacillus plantarum* exhibited prominent anti-inflammatory activity with respect to ibuprofen. Highest anti-inflammatory activity was observed at 48 h of incubation followed by 24 h. *In vivo* validation in broilers revealed that supplementation of postbiotics at 0.6% could serve as an alternate to in-feed antibiotics. The postbiotic metabolites are species-specific and their benefits relies on definite dosage.

Nutrition optimized for chickens and ducks: The body weight gain and feed efficiency improved, and stress indices reduced in broiler chicken with supplementation of methyl donors like betaine (0.2%), B_{12} (0.1 mg), folic acid (4 mg) or biotin (1.5 mg/kg) in diet having no supplemental methionine. Samples of Black soldier fly (*Hermetia illucens*) larvae meal procured from different production were rich in protein (49.8–59.6%) and fat (22.1–38.4%) with good amino acid profile. Different bajra cultivars could totally replace maize in the diet of broiler chicken.

Duck feeds: For White Pekin ducks, 2,900 kcal ME per kg was optimum during 0–6 weeks. Wheat could be completely replaced by broken rice in the diets of White Pekin ducks during second year of laying. Replacement of fish meal by soybean meal adversely affected the performance of Khaki Campbell (KC) laying ducks. Ginger supplementation (1 g/kg) in feed of grower White Pekin ducks was beneficial in ameliorating arsenic-induced toxicity. In the integrated model, Kuzi ducks gained higher body weight in comparison to KC ducks.

Yak

Conservation of green forages: The ensiling technology for green forages was standardized and popularized to mitigate winter fodder crisis in high altitude areas of Arunachal Pradesh and Sikkim.

Physiology

Cattle

- A prototype of intra-vaginal wireless sensor device was developed for remote monitoring of calving process in dairy cows.
- Antibiogram of Frieswal bull semen revealed that Gentamicin and Spectinomycin can be used in semen extenders to control bacterial load as the bacterial isolates were sensitive to these two antibiotics.
- Embryo transfer technology (ETT) was initiated in Kankrej cattle for faster multiplication of superior germplasm. Out of seven embryos retrieved from two cows, five good-quality embryos were transferred into four recipients.
- Establishment of one OPU-IVF pregnancy of Sahiwal cow.

Metabolic changes during diverse environment: The metabolic changes occurring due to summer stress were also evaluated in different dairy cattle breeds; and a total of 40 metabolites were identified. Metabolites involved in amino acid metabolism were present in higher concentration in native cows. Results suggested that summer stress can cause metabolomic shifts in cattle with different genetic background. The hierarchical clustering and PLS-discriminate analysis based on level of metabolites grouped in native cows differently than that in exotic and crossbred cows.

Buffalo

- Multiplication of elite buffaloes by cloning and ovum pickup techniques.
- Five pregnancies from cloned embryos in buffalo; (4 from a single breeding bull, 1 from an elite buffalo producing > 3,800 kg milk).
- Six calves born through AI using semen of cloned bulls.
- Seven pregnancies through AI from semen of cloned bulls are ongoing.

Buffalo pregnancy diagnosis kit Preg-D: The Preg-D kit is the prototype of a urine based novel technique for pregnancy diagnosis in dairy animals. The method (kit) gives high accuracy around days 30–40 of pregnancy. Tested in over 1,000 samples, the kit has an overall accuracy, sensitivity and specificity of about 80%, 90% and 77% respectively.

- Buffalo Saliva Scope, an estrus identification kit was developed.
- The buffalo cloned calf MU-8061 was born on 06.12.2020. The cloned embryos were produced using elite bull (MU-2558) donor cells. After completion of gestation period of 317 days, a

live, normal and healthy calf was born with body weight of 23 kg.

The transcriptome analysis revealed that the buffalo sperm carry transcripts for 6825 genes. The signature transcripts regulating buffalo sperm fertility were identified. It was evident that cryo-preservation process affected the quality and quantity of sperm transcripts. Mitochondrial and stress responsive genes were upregulated in sperm during cryo-stress.

Sheep

The study on modulation of sexual differentiation in embryos altering oxidative status of *in vitro* culture system, indicated that developmental potential of female ovine embryos was affected during *in vitro* embryo production by the activation of apoptotic pathway. Supplementation of free radical scavengers to culture medium improved the developmental potential of female embryos by modulating the apoptotic pathways.

Goat

Mechanisms of different levels of energy and protein influencing immune responses in goats was studied. The energy and protein reduction below 70% negatively influenced the plasma HSP70, leptin, glucagon, BHBA, GH and LH levels. The energy component of the diet significantly influenced expression pattern of *TLR1*, *TLR3*, *TLR6*, *TLR7* and *TLR8* genes in Salem Black goats.

Improved post-thaw motility: The post thaw progressive sperm motility increased more than 13.5% in 3 µM biotin than the control group. The post thaw sperm acrosome intactness was protected more than 16.82% in 3 µM biotin than that in the control group.

Pig

Boar fertility: Putative markers for boar fertility were identified and are being evaluated to explore its utility. A composite index of fertility to evaluate boars was developed. Low cost semen preservation tool was standardized and evaluated for the maintenance of controlled temperature (15–17°C) required for boar semen preservation. Biochemical characterization of boar seminal gel and its application for biostimulation in pigs was carried out.

Mithun

Follicular dynamics: The changes in concentrations of hormones during the estrous cycle in pubertal mithun, were studied. The animals were synchronized using GnRH and $PGF_{2\alpha}$ hormone injections on day 0 and day 7 respectively. The estrous behaviour was evaluated after 48 h of $PGF_{2\alpha}$ injection. The day when the dominant follicle disappeared and was replaced by corpus hemorrhagic was determined to be the day of ovulation (Day 0) for this experiment.

Semi-intensive mithun rearing units: An alternative package of practices of mithun rearing under a semi-intensive rearing system was developed. Under this system, the mithuns can be monitored by the owner regularly for growth, reproduction, health care, and breeding. Nine units were established during the reported period benefitting 334 mithun farmers.

Mithun rearing units—Mai village, Lower Subansiri district, Arunachal Pradesh

Poultry

Semen cryopreservation: Cryopreservation of semen from broiler (PB-2) line was explored. A fertility of 30.2 and 46.6% was obtained from 8% Ethylene Glycol (EG) and 6% dimethylformamide (DMF) respectively.

Oxidative stress: The role of uric acid in alleviating oxidative stress induced mitochondrial dysfunction during different production cycles in poultry was investigated. The mitochondrial membrane potential of duodenum and shell gland moderately decreased with a concomitant increase in the circulating levels of uric acid with age. High levels of uric acid in the untimely moulted birds disrupted the integrity of intestine and shell gland, which lowered mitochondria membrane potential with decreased capability of ATP synthesis and resulted in altered egg laying sequences. The results indicated that egg production could be a function of circulating levels of uric acid on the integrity of intestine and egg shell gland.

Breaking the seasonality of reproduction in guinea fowl: Guinea fowls are seasonal birds with average egg production of 90–110 eggs from March to September, i.e. during the period of longer day length and intense sunlight and almost no laying in winter. Seasonality of reproduction/ egg production is therefore, a major problem limiting its egg production and hindering large-scale commercial production of Guinea fowl. Dietary and photoperiod strategies were used to break the seasonality of reproduction during winter (December–March) aiming for reducing the age at first egg thereby extending the length of laying period and ultimately improving the total egg production. Exposure of guinea fowls to 18 h photoperiod with dietary inclusion of 20% protein, 120 ppm of vitamin E and 800 µg of selenium triggers onset of production with 53–56% hen day egg production, reducing the age of sexual maturity to 21 week, 71% fertility and 76% hatchability. These intervention increased overall egg production to around 200 eggs as against 90–110 eggs produced earlier.

Floor space: A floor space of 350 cm^2 during 0–2 weeks and 475 cm^2 floor space during 3–5 weeks was found optimum for KC ducklings.

Transport time for broiler chicken: More than 4 h transport duration significantly affected the meat quality, welfare and increase stress in broilers. A minimum pre-slaughter rest time of 30 min should be provided for recovery of the birds after transportation to overcome the stress and improve the meat quality. To check the welfare of broiler birds during transport among many parameters, an innovative welfare protocol, i.e. Run away test was also used. Wherein an iron corridor covered (10 ft) with gunny bags on the sides of the corridor was divided into three zones. The corridor opens with a start box and then was the stimulus bird zone. The other end of the corridor through which the birds runaway were littered with feed. The birds were introduced into the start box and the time spent by the birds in the stimulus bird zone was measured by an unobtrusive observer during the 10 min test. The birds with maximum transport stress will take more time to cross corridor.

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 with 3,262 district wise livestock disease outbreaks data from November 2020 to September 2021. The prediction results, risk maps, bulletins, and post-prediction maps were updated on NADRES web application (NADRES v2) and automated messages were sent to NADEN (National Animal Disease Epidemiology Network), ICAR-NIVEDI, centers and further disseminated through forecasting bulletin to all the State Animal Husbandry Departments and Department of Animal Husbandry and Dairying, GoI for initiating preventive action for diseases.

Machine Learning algorithms (15) were trained and tested for risk prediction of 13 livestock diseases covering 700 districts in India using livestock density, meteorological, and remote sensing variables. Models were evaluated for their performance using statistical indices, viz. KAPPA, ROC, and TSS. New initiatives like FARMERS Empowerment Through IT, Farmer Registration and Unified beneficiary Information System (FRUITS), a web application of NIC, Govt of Karnataka, a total of 1,407,823 SMS alerts were sent to farmers in Karnataka for different animal diseases (anthrax, babesiosis, black quarter, bluetongue, FMD, theileriosis).

The maintenance and updating of the National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) with 30,335 baseline, biological, disease outbreak, and hatcheries data were done.

Nation-wide sampling plans for sero-surveillance and sero-monitoring of FMD, brucellosis, and PPR for each state/UTs of the country were formulated and provided to DAHD, GoI, for strengthening surveillance system. The sampling plan for corona viruses surveillance (bovine corona virus, equine corona virus, porcine corona virus and feline corona viruses of dogs and cats) was also generated.

Sero-epidemiology: Serum samples from different animal species submitted from various states were screened for important livestock diseases. Of these samples, 6.6% were found to have anti-brucella antibodies. Serum samples from cattle, small ruminants, and pigs were screened for BoHV (IBR), PPRV and CSFV antibodies, of which 45.9, 48 and 38.1% showed positive reactivity for respective antibodies. Bovine samples were tested for antibodies against *Trypanosoma evansi* and *Fasciola gigantica* and 24.08 and 33.5% samples respectively, were found to have antibodies.

Serum samples from sheep, goats, bovine, pigs, dogs, and human, submitted from 8 states, were screened for *Leptospira* antibodies. The seroprevalence was in 17.6% cattle and 17.3% goats in Andaman and Nicobar Islands, whereas in Assam, the seroprevalence was observed in 26.2% cattle, 14.3% buffaloes, 19.1% goats, 23.5% sheep and 18.6% pigs.

Diagnostics

Indian Patent (No. 354817 – for lateral flow assay-based penside diagnostic kit for human brucellosis for detecting anti-*Brucella* IgM and IgG antibodies in serum/blood of humans), Indian Patent (No. 361741 – Recombinant VSG and Monoclonal antibody-based competitive inhibition ELISA for detection of antibodies against *Trypanosoma evansi*), and Indian Patent (No. 369790 – Monoclonal antibody-based double antibody sandwich ELISA for the detection of *Trypanosoma evansi* antigen in animals) were granted to ICAR-NIVEDI on 30 December 2020, 18 March 2021 and 21 June 2021, respectively.

Veterinary vaccines

Marker vaccine candidate for Peste des petits ruminants (PPR): A marker vaccine candidate for PPR was developed through reverse genetics. The backbone of the PPR vaccine virus, PPRV/Sungri/96 was used, as this attenuated virus has a global reputation and is being successfully used for PPR control in India for over two decades. Amenable epitopes in the parent virus were identified and modified through a combinatorial approach involving computational analysis and genetic engineering. The epitope modified viruses retained all the growth characteristics and production scalability of the parent virus in addition to possessing the required antigenic differences to qualify as a marker vaccine candidate. The vaccine candidate was also tested in target animals and proved to be safe and efficacious like that of the parent vaccine strain.

Duck plague vaccine: An Indian virulent strain of duck enteritis virus (DEV) was attenuated by serial passage in primary CEF cell culture. The attenuated duck plague vaccine candidate (DEV/India/IVRI-CEF

attenuated) was completely safe, and afforded 100% protection against challenge infection.

Detection of FMD non-structural protein antibodies: Foot-and-mouth disease (FMD) is controlled through mass vaccination of livestock. An improved blocking ELISA for detection of foot-and-mouth disease non-structural protein (NSP) was developed. It can be used as single assay platform to screen samples from different species of FMD susceptible animals. The cost of testing is cheaper with nearly 6 times less compared to similar imported kit. The assay was validated in an international laboratory, Wageningen Bio-veterinary Research, Lelystad, Netherlands, and tested on sera specific to all 7 serotypes of FMD virus.

Blocking ELISA kit developed for detection of foot-and-mouth disease

Detection of group-specific antibodies against VP7 protein of BTV: A colloidal gold nanoparticle-based lateral flow immunochromatography assay (LFIA) was developed to detect the group-specific antibodies to BTV in serum samples and compared with commercial competitive-ELISA (c-ELISA) kit using samples from sheep, goats, cattle, and camel segregated as positive and negative by the reference c-ELISA. The relative diagnostic sensitivity (DSn) of 95.2% with 91.6–97.6 (95%)) confidence interval and relative diagnostic specificity (DSp) of 99.6% with 97.8–100 (95%) confidence interval were obtained for the optimized LFIA. The agreement between the LFIA and the c-ELISA was excellent as indicated by the kappa coefficient value with 95% confidence interval. The recombinant protein G based LFIA is a sensitive, specific, rapid, one-step test that can be used in the field or poorly equipped laboratories for serological diagnosis and sero-surveillance of bluetongue in multiple susceptible species.

Therapeutics

Canine parvovirus enteritis: Therapeutic efficacy of a chicken egg yolk based immunoglobulin, IgY-P @ 410 IU/kg bwt, was evaluated in naturally CPV-infected dogs. The clinical score and fecal virus load decreased remarkably over the treatment period of 7 days. It was concluded that anti-CPV IgY-P serves as a promising therapeutic for the management of CPVE dogs where no specific treatment is available.

Mobile Apps launched

IVRI-Biosecurity and Biosafety (Jaiv Suraksha) Mobile app: This app is intended to impart knowledge and skills to livestock and poultry farmers, field veterinarians and healthcare personnel on various aspects of biosecurity and its advantages, detailed information about the measures pertaining to biosecurity and biosafety in dairy, pig and poultry farms, viz. location and design of farms, restricted movement, isolation and quarantine, cleaning and disinfection, management of feed and water, disposal of carcass, disposal of clinical and other wastes, disposal of farm effluents/manure, personal hygiene, health management, reproductive management, documentation and record keeping, actions during disease outbreak and examples of disinfectants used. An electronic score to assess the biosecurity and biosafety of a farm has also been provided. This app is presently available in English and Hindi languages. (Link for the App: https://play.google.com/store/apps/details?id=com.icar.ivri.iasri.biosecuriy).

IVRI-Research Method Tutorial App: The IVRI-Research Methods Tutorial App, is basically a Multiple Choice Questions (MCQ) based Drill and Practice educational learning tool targeted to impart knowledge and skills to students in the research methods especially for social sciences. The app will be useful for the students enrolled in PG degree programmes in various social science disciplines in various universities and colleges across the country. It will also be useful for students preparing for various competitive exams. (Link for the App: https://play.google.com/store/apps/details?id=com.icar. ivri.iasri.tutorialc2app.

Equines

EHV-2 and EHV-5 in asymptomatic horses: Infections due to g-EHV equid gamma-herpesvirus are

Emetine can be repurposed to treat COVID-19

Emetine is a FDA-approved drug, which is used to treat amebiasis, a parasitic disease. It is commercially available in both tablet and injectable form. In initial cell culture-based study, emetine treatment decreased ~10,000-fold SARS-CoV-2 (both alpha and delta variants) titres in Vero cells. Based on these encouraging results, antiviral efficacy of emetine against infectious bronchitis virus (IBV, also known as chicken coronavirus), was evaluated. Emetine completely protected chicken embryos against lethal challenge with IBV.

Mechanistically, it was demonstrated that emetine interferes with the synthesis of viral proteins without inducing any toxicity (side effect) to the host cells. In order to stop synthesizing viral proteins, emetine inhibits binding of eIF4E (a cellular protein required for the initiation of protein translation) to the viral mRNA. Further, molecular docking and molecular dynamics simulation studies suggested that emetine may bind to the cap-binding pocket of eIF4E, in a similar conformation as m7-GTP binds. In summary, a potent antiviral efficacy against SARS-CoV-2 in the cell culture, ability to protect chicken embryos against lethal IBV infection, together with molecular docking and molecular dynamics simulation studies suggested that emetine could be repurposed to treat COVID-19.

associated with respiratory diseases, pharyngitis, enlarged lymph nodes, nasal discharge, coughing, fever, lack of appetite and poor performance. EHV-2 is also associated with kerato-conjunctivitis and EHV5 with equine multi-nodular pulmonary fibrosis syndrome. Taqman probe-based real-time PCR assay was developed and used to detect the occurrence of EHV-2 and EHV-5 in young horses. On testing of DNA samples isolated from swabs, 59 (67.04%) were positive for EHV-2, 42 (47.72%) for EHV-5 and 38 (43.18%) were positive for both EHV-2 and EHV-5 for the first time in India.

Novel genomic constellations of *Streptococcus equi:* *Streptococcus equi* is the causative agent of strangles. The organism has been isolated from many diseased animals but not characterized at molecular level to ascertain the diversity of microbial population in India. Out of the total 41 *S. equi* isolates, 9 isolates had novel genomic constellations that have not been reported earlier.

Phylogenic relationship of Indian *Burkholderia mallei* strains: Genetic diversity of Indian *Burkholderia mallei* strains isolated from glanders affected equines was investigated. Phylogeny revealed that recent isolates circulating in India were closely related to each other. *B. mallei* originating from Uttar Pradesh was closely related to isolates obtained from Himachal Pradesh (Ghaziabad/Mandi- 3595/3855, Baghpat/Kangra- 4365/3932, Auraiya/Solan-4517/3081), Maharashtra (Ghaziabad/Buldhana- 4508/4600) and New Delhi (Kasganj/Mongalpuri- 3701/4629, Kasganj/Vijay Vihar- 3703/4638). The present findings and surveillance data suggested that Uttar Pradesh is the most glanders prone area.

Cross neutralization of wild type and Delta strains of SARS-CoV-2 from Hisar (India): Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has rapidly evolved to generate several antigenic variants. These variants have raised concerns whether pre-existing immunity to vaccination or prior infection would be able to protect against the newly emerging SARS-CoV-2 variants or not. SARS-CoV-2 were isolated from the COVID-19 confirmed patients in the beginning of the first (April/May 2020) and second (April/May 2021) wave of COVID-19 in India (Hisar, Haryana). Upon complete nucleotide sequencing, the viruses were found genetically related with wild-type (WT) and Delta variants of SARS-CoV-2, respectively. The Delta variant of SARS-CoV-2 produced a rapid cytopathic effect (24–36 h as compared to 48–72 h in WT), had bigger plaque size and a shorter life cycle (~6 h as compared to the ~8 h in WT). Also, the Delta variant achieved peak viral titers within 24 h as compared to the 48 h in WT. These evidences suggested that Delta variant replicates significantly faster than WT SARS-CoV-2. The virus neutralization experiments indicated that antibodies elicited by vaccination are more efficacious in neutralizing WT variant in comparison to the Delta variant.

Pig

Sero-positivity of JEV in pigs: Seasonal distribution of JE sero-positivity in pigs was evaluated in Assam. More than 3200 field serum samples from nine JEV endemic districts of Assam were screened for detection of JEV antibodies and the highest sero-positivity (~9%) of JEV antibodies were recorded in samples collected during June–July (monsoon season). Most prevalent mosquito vectors identified were *Culex tritaeniorhynchus*, *Cx. Quinquefasciatus*, *Cx. whitmorei*, *Mansonia* spp. and *Cx. gelidus*.

Porcine circovirus type-II and porcine parvovirus: LAMP assay based diagnostic kits were developed for detection of porcine circovirus type-II (PCV-2) and porcine parvovirus (PPV). Multiplex PCR assay for simultaneous detection of porcine circovirus-2 (PCV-2), porcine parvovirus (PPV) and classical swine fever virus (CSFV) was also developed. Further, multiplex PCR assay was developed for detection of MRSA from pork samples.

Poultry

Avian leucosis virus: The overall positivity of avian leucosis virus (ALV) carriers was 15.6% in Pureline chickens by p27 antigen ELISA. Kadaknath had the highest percentage of ALV shedders. The multiplex PCR technique was developed, optimized and validated with field clinical samples for rapid and simultaneous detection and differential diagnosis of avian tumor diseases such as Marek's disease, Avian leukosis and reticuloendotheliosis. The caecal microbial diversity of Krishibro broiler chicken supplemented with and without antibiotic growth promoters revealed functional categories of carbohydrates, clustering based subsystems and protein metabolism as the predominant categories with >10% abundance.

Avian influenza H5 virus antigen detection: India has been experiencing continual outbreaks of H5 subtype of highly pathogenic avian influenza (HPAI) virus since 2006 resulting into great economic losses to the poultry industry due to heavy mortality, trade restrictions and culling. ICAR-NIHSAD developed the Lateral Flow Rapid Test kit for pen-side detection of avian influenza H5 virus antigen in tracheal and cloacal swab samples from suspected chicken flocks for preliminary screening and diagnosis at the farm level. The test is simple to perform at low cost, and provides rapid diagnosis within 20 min. The kit was released by ICAR on 8 Aug 2021.

Whole genome sequence analysis of bacteriophage: The complete genome analysis of bacteriophage VTCCBPA139 against *Proteus mirabilis* was carried out. This phage was isolated from poultry litter against a drug resistant *P. mirabilis*. The phage genome is ~94 kb with 95.88% similarity with *Proteus* phage PM135. The genome has 37.69% G+C and carries 153 predicted genes out of which, 136 were annotated and 17 tRNAs were found in the genome.

Foot and mouth disease

ICAR-Directorate of Foot and Mouth Disease was recognised as a 'FAO Reference Centre of Foot and Mouth Disease' in place of its previous recognition as

'FAO Reference Centre of Foot and Mouth Disease for South Asia'.

Sero-surveillance and sero-monitoring: Under National FMD serosurveillance, 28,284 bovine serum samples from around the country were analyzed to determine the prevalence of NSP-antibody (NSP-Ab) positive animals. Overall seropositivity was found in 16.2% of the samples tested. In general, over the year, a decline in NSP antibody prevalence was observed in the country, which showed positive impact of FMD control program. For FMD seromonitoring under NADCP, a total of 90,154 serum samples were examined to assess the efficiency of immunization. There was a decrease in protective antibody tires.

Development of new diagnostics for FMD: A SYBR green-based FMDV-3D^{pol} specific one-step real-time RT-PCR (rRT-PCR) test was developed for pan-serotype identification of FMD virus. The limit of detection of FMDV RNA was 10^{-2} $TCID_{50}$/50 µl, which is 10 times more sensitive than the traditional agarose gel electrophoresis-based RT-multiplex PCR (RT-mPCR). A perfect concordance was observed between the new rRT-PCR and traditional RT-mPCR on viral RNA in the archived FMDV cell culture isolates tested. Therefore, the SYBR green-based 3D^{pol} specific one step rRT-PCR could be considered as a valuable assay with higher diagnostic sensitivity to complement the routine assays being used for FMD virus diagnosis in India.

A new serological assay (IgM I-ELISA) was developed to detect anti-FMD IgM antibodies specific for FMDV 2B NSP. This test can be used to detect persistently infected animals as it is not feasible to test the oro-pharyngeal fluid (OPF) samples while screening a large animal population for detection of carrier state of FMD. Percentage of positivity (PP) values from 507 archival serum samples were analyzed through receiver-operating curve (ROC), where the cut-off point was found to be 48 PP and the diagnostic sensitivity and specificity at this cut-off was found to be 97.98% and 96.67%, respectively.

Molecular epidemiology: The capsid coding region (P1/VP1) sequences of 13 FMD viral strains were inferred and added to the sequencing database of Indian FMD viruses (10 serotype O and 3 serotype Asia 1). The O/ME-SA/Ind2001 lineage since its first report in the year 2001 has diversified into at least five sub-lineages (Ind2001a, b, c, d and e). The phylogenetic comparison of serotype O isolates with representative strains revealed emergence of sub-lineage O/ME-SA/Ind2001e during the year 2015 in India. The emerging lineage O/ME-SA/Ind2001e was responsible for sporadic incidences during 2015–2017, before causing outbreaks in epidemic proportion during the year 2018. In serotype O, the exclusive dominance of the O/ME-SA/Ind2001e lineage was discovered during 2020.

Emergence of exotic and emerging animal diseases SARS-CoV-2 (COVID-19) infection in lions: In May 2021, 8 out of 10 lions, reported to be sick with respiratory symptoms, in the Arignar Zoological Park, Chennai, were tested positive by real-time RT-PCR for SARS-CoV-2 (COVID-19). To further confirm the diagnosis and genetic characterization, whole genome sequences of SARS-CoV-2 from 4 lions were generated using MinION from Oxford Nanopore Technologies. Phylogenetic analysis of the spike protein sequences showed that the spike protein sequences contained 9 amino acid substitutions and 2 deletions compared with the Wuhan-Hu-1 strain, and are typically matched with a delta variant (B.1.167.2) of SARS-CoV-2. The study reported the first confirmed natural SARS-CoV-2 infection in Asiatic lions in India, caused by a variant of concern (VOC delta, B.1.167.2 lineage).

Lumpy skin disease viruses (LSDV): Lumpy Skin Disease (LSD) emerged in cattle in August 2019 in Odisha State and spread rapidly to other areas. The phylogenetic analysis of 4 complete genes, viz. GPCR, RPO30, P32 and EEV of 12 LSDV isolates revealed that all the Indian LSDV isolates from 2019 outbreaks were very closely related (99.7–100%) to the historical Kenyan NI-2490/Kenya/KSGP-like field strains, than the contemporary field strains circulating in Africa, Middle East, Central Asia and Europe and the vaccine-like recombinant LSDVs linked to field outbreaks in Russia and China. Importantly, the study demonstrated that LSDV strains involved in 2019 outbreaks in India and Bangladesh are very similar in GPCR (99.7%), RPO30 (100%) and partial EEV (100%) sequences, indicating a common exotic source of LSDV introduction. The findings provide new insights into the global LSDV epidemiology, and demonstrated change in genetics of globally circulating LSDV field strains.

African swine fever viruses: The occurrence of African Swine Fever (ASF) was confirmed for the first time in India in 2020, in Arunachal Pradesh and Assam. Subsequently, 89 out of 131 samples received from Meghalaya, Manipur, Nagaland and Mizoram states were found positive for ASF virus (ASFV). To genetically

Herbal prototype (Brucare) for checking *Brucella* shedding

A significant reduction in shedding was noticed in *Brucella* positive animals from 21 days post treatment with the Herbal Prototype. In the field conditions, where no available mechanism is there for the goat keeper to control brucellosis, such herbal drug based package of practice could be a boon to the farmers in controlling *Brucella* abortions as well as containing the risk of zoonosis.

characterize Indian ASFV, 9 representative viruses isolated from these states were analyzed in three genomic regions, namely, partial B646L gene (encoding the p72 protein), complete E183L-gene (encoding the p54 protein) and the central variable region (CVR) within the B602L gene. Genetic analysis showed that all the nine Indian ASFV isolates shared 100% nucleotide and deduced amino acid sequence identity in all the three regions studied. In the B646L gene based phylo-dendrogram, all the Indian ASFV isolates grouped within genotype II ASFV. Furthermore, within genotype II, Indian isolates shared 100% nucleotide sequence homology with contemporary ASFV from Asia and Europe, including China, South Korea, Vietnam, Georgia, Hungary etc. The results confirmed the spread of Indian ASF viruses amongst north-eastern states of India.

H5 avian influenza viruses: Complete genome sequence of 4 H5N1 highly pathogenic avian influenza (HPAI) viruses and 7 H5N8 HPAI viruses isolated from chickens, ducks, crows, wild birds and bar-headed goose during December 2020 to March 2021 in different epicenters, was determined. In the hemagglutinin gene phylogeny, all H5N8 viruses and H5N1 virus isolated from bar-headed goose clustered with clade 2.3.4.4b viruses and all other H5N1 viruses clustered with Clade 2.3.2.1a viruses. While they clustered within clade 2.3.4.4.b with contemporary isolates from England, Italy, Russian Federation, The Netherlands and Sweden, the Indian viruses isolated during 2020–21 are distinct from the other H5N8 viruses including those detected in India in 2016, indicating independent introduction. However, the H5N1 viruses from clade 2.3.2.1a isolated during 2020–21 grouped with contemporary H5N1 viruses isolated from SAARC regions including India, indicates cross-border movement and persistence of the H5N1 virus, which highlights the need for continuous active surveillance.

Fisheries

Development of biofloc starter consortium: Developed a starter microbial consortium named 'CIBAFLOC' which facilitates *in situ* bioremediation, cleaning of nitrogenous wastes in the rearing water and getting converted into nutrient-rich microbial biomass. In biofloc technology, microbial biomass serves as a natural *in situ* feed for the farmed species and improves nutrient recovery and production. This most sought-after biofloc technology has been optimized for shrimp farming under Indian agroclimatic conditions.

Development of cyprinid herpesvirus-2 (CyHV-2) vaccine: Goldfish hematopoietic necrosis viral disease (GHNVD) has led to worldwide economic losses in goldfish aquaculture. Virus was inactivated with formalin and the vaccine for Cyprinid herpesvirus (CyHV-2) was developed by using Fantail goldfish fin (FtGF) cell line for its propagation. The goldfishes were intraperitoneally injected with 300 µl of vaccine. Formalin-inactivated CyHV-2 vaccine showed a significant up-regulation of the genes CD8 and IFN-λ by the 6^{th} h post-vaccination onwards. The relative per cent survival for immunized fish was 74.03%. These results have proven that the formalin-inactivated vaccines were efficient and it resulted in triggering the immune gene expression in goldfish.

Development of vaccine against viral nervous necrosis infecting Asian seabass: Viral nervous necrosis (VNN) is an acute viral disease affecting more than 120 species of marine, brackishwater and freshwater fish causing up to 100% mortality in larval and juvenile fishes. The disease is caused by the nervous necrosis virus (NNV), transmitted both vertically and horizontally. Infected adults remain carriers and transmit the virus to offspring through eggs. The practical way to control the disease and prevent vertical transmission is to vaccinate fingerlings and adult fish. A recombinant vaccine, 'CIBA-Nodavac-R' against VNN was developed. It is an injectable vaccine and can effectively prevent VNN caused by RGNNV (red-spotted grouper nervous necrosis virus) in fingerlings and prevent vertical transmission in brooders. The vaccine is safe and efficacious.

Established milkfish brain cell line MFB-1 for *in vitro* propagation of beta nodavirus: Created a new cell line MFB-1 from the brain of milkfish (*Chanos chanos*). The MFB-1 cells were characterized by karyotyping (2n=32). The cells were confirmed using cox1 marker gene and sequence submitted to NCBI database (Genbank accession no. MN836380). The MFB-1 cell line was established successfully with stable growth. The established MFB-1 cell line was inoculated with the RGNNV strain of beta nodavirus and the virus was adapted by five passages. Nested RT-PCR confirmed the viral presence. Thus, MFB-1 cell line was found suitable for *in vitro* multiplication of beta nodavirus. ❑

9. Mechanization and Energy Management

Tractor operated drip lateral-cum-plastic mulch laying machine

A tractor operated variable width raised bed drip lateral-cum-plastic mulch laying machine was developed and evaluated. This machine is able to form bed of 0.6 to 1.0 m in width and 0.15 m in height. A 45 HP tractor was suitable for operating the system. The field capacity and field efficiency of the machine were 0.26 ha/h and 65%, respectively, at a forward speed of 0.55 m/s.

Laboratory model robotic transplanter for plug-type vegetable seedlings

A laboratory model of robotic transplanter was developed for plug-type vegetable seedlings. The seedling pick-up mechanism is integrated with the manipulator with computer programming using Microchip-16F877. The transplanter is under testing and evaluation.

Tractor operated garlic weeder

A tractor operated 19 row garlic weeder was developed. Effective field capacity and field efficiency of the weeder are 0.29 ha/h and 81.2%, respectively, at 2 km/h forward speed of operation. Average weeding efficiency and plant damage by garlic weeder are 69.6% and 0.1%, respectively.

Garlic harvester for raised beds

A tractor operated garlic harvester was developed for harvesting of garlic crop grown on raised beds (up to 150 mm height and 1,200 mm top width). The garlic harvester was evaluated in the garlic crop sown at 100 mm row to row and plant to plant spacing at 1.93 km/h forward speed and working depth of 60–80 mm. Effective field capacity of the machine is 0.21 ha/h at field efficiency of 72%. The harvesting efficiency and bulb damage during the operation are 97% and <0.5%, respectively.

Tractor operated pigeon pea harvester

A tractor front mounted hydraulically operated two-row pigeon pea harvester was developed. The harvester was evaluated in the plain field. The field capacity was 0.55 ha/h and operating cost was ₹ 930/ha. It saved 40% cost and 96% labour when compared with manual method of harvesting.

Lightweight multi-crop thresher for hills

A lightweight multi-crop thresher was developed for threshing wheat, paddy, minor millets, and amaranth crops commonly grown in Uttarakhand hills; 1 hp single phase electric motor was used to run the thresher. The threshing capacity of the machine for wheat, paddy, barnyard millet, finger millet and amaranth, was observed as 34, 75, 58, 54, and 30 kg/h, respectively. The threshing efficiency was more than or equal to 98% for these crops. Cleaning efficiency was more than 95% for the above crops. The multi-crop thresher would benefit hill farmers by saving time and labour and reducing the drudgery involved in the traditional/manual threshing operations.

Tractor operated drainage trencher for laying sub-surface pipes

A tractor operated drainage trencher for laying sub-surface pipes was developed and evaluated. The developed trencher can make the trench up to the depth of 1.0–1.1 m with width of 150–160 mm. The operating speed of the trencher was 0.3 km/h. Machine can dug the trench at the rate of 250–365 m/h with depth ranging from 250 to 1,000 mm and lay a drainage pipe subsequently at desired grade. The cost of the developed trencher was worked out to be ₹ 300,000 and cost of operation is about ₹ 1,300/h. The field efficiency of the machine was 81.2%. The developed unit can save the cost over existing machine to the tune of 40–50%, and will increase the annual use of the tractor.

Participatory promotion of climate smart agriculture machinery in selected village cluster of Madhya Pradesh

The climate smart machinery such as roto-till-drill, broad-bed and furrow planter, laser land leveller, ridge and furrow planter and mole drainage technology were identified to overcome the adverse effect of climate change and degrading natural resources. Roto-till drill for wheat and broad bed bund farmer planter was identified for soybean crop. The specific energy for roto-till drill and conventional farming systems are 5.5 and 6.1 MJ/kg of production, respectively. The total input energy in wheat production after adopting roto-till drill (21.1 GJ/ha) is about 39% lower as compared to conventional practices (34.9 GJ/ha). The carbon emission in roto-till drill is 1,670 kg of equivalent C/ha which is 9% less in comparison to conventional practice (1,834 kg of equivalent C/ha).

Deep learning algorithm development for identification of water stress conditions in field crops

A study was envisaged to explore the potential of deep convolution neural networks (DCNN) models based on deep learning (DL) techniques for identification of stress and non-stress conditions in maize and wheat crops. The RGB images (>3,000 for each crop) of stressed and non-stressed crops of wheat and maize were captured using digital camera. The training accuracy in identification of water stress was 50.54, 68.82 and 64.52% for wheat and 55.32, 98.30 and 92.86% for maize using AlexaNet, GoogLeNet and Inception V3, respectively. The GoogleNet outperformed the AlexNet and Inception V3 in classification of water stress with an accuracy of 68.82 and 98.30% for wheat and maize crops, respectively.

RGB-thermal imager for water stress assessment in field crops

Thermal imagers are useful tool for crop stress monitoring and real time application of irrigation scheduling. It can be used for measuring surface temperature of fruits, seeds, vegetables, heating problems in machines and detection of human body surface temperature. The commercially available thermal imagers have limitations for their application in spatial data collection along with location coordinates and real time data processing. In addition, they are costly and can not be integrated with actuation system for real time communication. To overcome these issues, a RGB-thermal imager was developed. The RGB, thermal and GPS modules were attached directly with micro-controller board. The Raspberry pi board was driven by NOOBS operating system having 64 GB memory. The developed RGB-Thermal imager provides real time data collection, using AMG8833 temperature sensor having FoV (60°) and accuracy 2°C, better than commercially available thermal imagers. GPS module interfaced with RGB-Thermal imager can be used to assess spatial variability. The continuous recording of data helps in real time monitoring and controlling of actuators. Overall, the developed module is user friendly, robust, low cost (<₹ 15,000) and unaffected by environmental parameters (temperature, rainfall).

Tractor operated tobacco seedling transplanter with spot application of water

A tractor operated tobacco seedling transplanter with spot application of water was developed. The nursery grown seedlings in the protrays can be dropped through the metering mechanism by two operators who are seated behind the equipment. A shoe type soil opener opens up the soil. The seedlings, which is dropped down from the seedling placement mechanism will be placed in the opened-up soil. The soil compaction wheels which follows the soil opener closes the soil thereby giving stability to the seedlings. The plant to plant spacing can be adjusted to 50 cm, 60 cm and 75 cm to suit the demand of different region. Similarly, row to row spacing can be adjusted to 65 cm, 70 cm and 100 cm. Both the seedling dropping mechanism and watering mechanism will be actuated through cam arrangement fitted in the transmission system to synchronize seedlings dropping and watering. The quantity of water applied per plant is 200–250 ml. The field capacity of the equipment is 0.2 to 0.3 ha/h and the missing percentage is to the tune of 2–3% at a working speed of 1.5 km/h. The plant establishment was more than 95%. Saving in labour is 85%.

Tractor operated pigeon pea transplanter

A tractor operated pigeon pea transplanter was developed, as a new tool for increasing productivity. The row-to-row spacing can be set either 90 cm or 105 cm and plant spacing can be changed by adjusting metering mechanism. The unit weighs 170 kg, and it can be operated by 35 hp tractor under the ploughed soil condition. Its field capacity is 0.13 ha/h with field efficiency of 75.78% and wheel slip of 8.2%. The cost of operation is ₹ 8,000/ha. The break-even point and payback period are 118 h/year and 0.8 year, respectively. It is recommended for medium and small farmers of pigeon pea cultivation in the country.

Small tractor operated EPN applicator

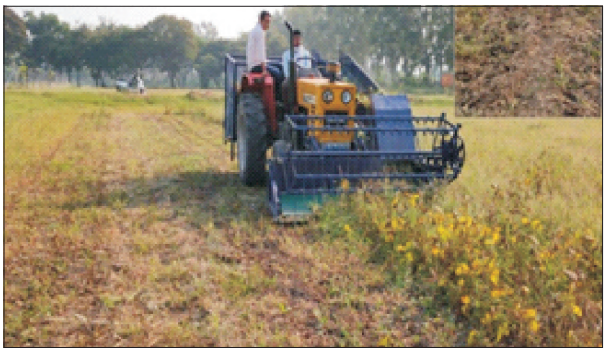
EPN (Entomo-pathogenic nematodes) application is recommended to manage white grub in sugarcane crop. At present, farmers follow spot application method which involves making 125 mm deep holes using crowbar and followed by dropping the EPN solution manually to control white grub. This results in non-uniform quantity of EPN solution in sugarcane root zones. Therefore, a small tractor (13.4–17.9 kW) operated EPN applicator was developed to reduce the drudgery of workers and uniform application of EPN solution. The 150 l capacity tank consists of an agitator and two outlets for EPN solution. The speed of the agitator shaft and discharge rate can be adjusted using control units. It applies EPN solution at the rate of 30–32 Infective juveniles/ml (IJs/ml) from each outlets at root zone of sugarcane crop to control white grub and has an effective field capacity of 0.18 ha/h. The cost of operation of the equipment is ₹ 2,550/ha, and results in cost saving of 47% as compared to manual method.

Paper-tape vegetable transplanter

A tractor-operated multi-row paper-tape vegetable transplanter was developed to save on labor, time and cost in vegetable production. It is a 6 row transplanting machine mounted on 3-point linkage of tractor. The row spacing of the machine can be adjusted with a minimum limit of 30 cm and six rows can be planted in one pass. It can be operated using a 24 HP tractor at a forward speed of 2.1 km/h. The row to row and plant to plant spacing was 30 and 16 cm respectively. The field capacity of the transplanter was 0.25 ha/h and fuel consumption of 2.8 l/h. The tilted planting percentage was 3.14%.

Integrated system for harvesting and conveying of bunch crops

A tractor operated integrated harvesting-cum-conveying machine having cutter bar width of 2,120 mm was developed. It is a modified vertical conveyor reaper with an integrated conveying system for conveying cut crop to a collection box/trailer. The machine was evaluated for harvesting of soybean, black gram and green gram crops. The average height of cut, effective field capacity and field efficiency of machine are 66–80 mm, 0.25 ha/h and 78%, respectively, at 1.5 km/h forward speed. The harvesting losses are 1.5–2.9% for soybean, black-gram and green-gram crops. The estimated cost of the machine is ₹1.00 lakh and cost of operation is ₹711/h. The integrated harvesting-cum-conveying system can give economic benefit and time saving of 49 and 60%, respectively, as comparison to manual harvesting of bunch crops by sickle.



Battery operated pruner for horticultural crops

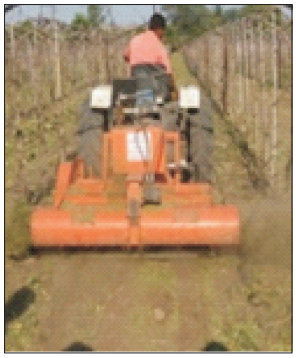
A battery operated pruner for horticultural crops was developed. The device is provided with telescopic pipe (145–400 cm) to reach the required height. The developed device was tested on ber, guava, wax apple and mango. The device could cut 11.25 mm thick twig of ber tree in 24.60 sec, 12.82 mm thick twig of guava tree in 45.15 sec, 11.64 mm thick twig of wax apple tree in 27.50 sec, and 14.38 mm thick twig of mango tree in 34.95 sec respectively. The cost of machine is ₹ 2,625 and cost of operation ₹ 39.48/h.

Battery operated lightweight interculture tool/weeder

A light weight battery operated two row weeder was developed for fields where heavy machinery can not enter in fields. The weight of machine is 35 kg. The testing was carried out in okra field. Average depth of operation, field capacity and weeding efficiency of the machine were 60 mm,

0.012 ha/h, and 84% at 0.45 km/h speed of operation, respectively. The estimated cost of machine is ₹21,000.

Tractor operated horizontal shredder for orchards



A tractor operated Phule horizontal shredder for grape vineyards/ orchards was developed. It is useful for shredding of pruned material in grape vineyard and orchards and spreading it evenly on the beds of orchard. The shredded material discharged on both sides. The effective field capacity of the machine was 0.47 ha/h. The net saving of money by using the machine over traditional method is ₹2,888/ha (72%).

Tractor operated hydro-mechanically controlled offset orchard manager

The tractor operated Phule hydro-mechanically controlled offset orchard manager was developed to break beds in between the inter spaces of adjacent trees in orchards besides cutting of old roots that help in new root formation and facilitate proper aeration to root zone of the trees. When sensor rod touches the trunk of tree, it retracts and after wrap up action around tree trunk, it is extended due to hydraulic relief valves. During this process cycle of retraction and extension, the rear mounted plough bottom breaks the bed between interspaces in adjacent trees facilitating aeration to the root zone as well as simultaneously cutting old roots for enhanced growth of trees with application of manure for soil enrichment. The effective field capacity of the machine was 0.127 ha/h. Net saving by using the machine over traditional method was worked out to be ₹3,910.00/ha (48%).

Pollinator for greenhouse

Greenhouse provides a desired climatic condition for crops but at the same time, has obstacles for natural pollination. A pollinator was designed on the principle of a pulsating air jet for pollination. Three pulsation units (3D printed) were used to provide varied air pulsation frequency and angular movement to cover the complete flower bed. An operator in the greenhouse alleys can easily move the unit. The developed unit is compared with hand pollination and pollination by a blower in tomato crops. The highest pollination efficiency (83.66%) was achieved at 1.99 m^3/min airflow rate, 23.50 Hz pulsation frequency and exposure time of 19.40 sec; an average yield of 19.52 kg was observed at 1.99 m^3/min of airflow rate, 22.25 Hz of pulsation frequency and exposure time of 15.78 sec in flowers of 5 m length sections. The yield was also higher with developed pollinators compared to pollination by a blower (36.6%) and controlled plot (95.7%). Cost of the pollinator is ₹ 15,000 and cost of operation is ₹ 400/ha as compared to ₹1,500/ha with manual hand pollination.

Girdling tool for litchi tree

In order to mechanize girdling, a selective wounding process that removes strips of bark of a litchi tree to increase fruit size and yield, a motorized girdling tool was developed. It mainly consists of a circular blade to cut the wood bark from the tree, safety cover to protect the operator from rotating blade, handle and a 12 V battery-operated motor. The time taken to complete one girdling (2–3 mm depth and 3–4 mm width) operation with the tool is 2–4 min as compared to 15 min with traditional knife. It was also demonstrated to litchi farmers in Muzaffarpur district for its popularization and adoption.

Health hazards of workers in rice/flour mill

The major problems in rice huller are noise and dust. The workers are mostly exposed to dust generated, which causes pulmonary diseases, eye irritation, nose conjunction, choking of throats, etc. Some of the workers cover the face with cotton clothes. Dust concentration in the rice mill at different distance is 1, 2, 3 and 4 m from the feeding site and found value of $PM_{2.5}$ (mg/m^3) is 362, 348, 293, 282 and 264 respectively. Similarly value of PM_{10} (mg/m^3) is 466, 442, 360, 341 and 322 respectively. A dust-arresting chamber was fixed in one of the rice-hulling unit so that dust can be arrested and thrown out. The intervention can reduce the dust concentration by 22%. Even then dust concentration level was more than safe limit. It is recommended that workers should use dust mask for proper safety.

Bullock drawn 4-row seed drill for millets

In Odisha, small and marginal farmers generally use manual broadcasting method for sowing of small seeds

(finger millet, small millet, sorghum; mustard, sesamum, linseed) after ploughing under upland condition. A four row bullock drawn seed drill for millets was developed. Cost of a seed drill is ₹22,000. The effective field capacity of seed drill is 0.12 ha/h at 1.85 km/h speed for sowing of finger millet. The draught and power requirement of the equipment are 378 N and 0.206 kW, respectively, which are within the draughtability of a pair of bullock/ buffalo.

Animal drawn straw collector

An animal drown straw collector was developed. It collects the straw from combine harvested rice field. Working width of implement is 1,067 mm. In a single pass, it can collect 5–8 kg straw from harvested field. Field capacity of the implement was 0.18 ha/h.

Bullock power sunflower thresher

A bullock power, rotary mode driven feed type sunflower thresher was developed. The average output of the thresher was 65 kg/h with efficiency of threshing as 99% and cleaning 85%. The speed of rotation of the thresher shaft (430 rpm), oscillating screen shaft (360 rpm) and blower shaft (270 rpm) is maintained with the bullocks moving at 1.9 km/h. The overall fatigue score of the bullocks was 13.5 after 1 h continuous operation, indicating that the equipment could be operated comfortably by them. The average power requirement for threshing was 0.29 kW. The average output of the thresher was 64.8 kg/h with efficiency of threshing as 98.7% and cleaning 84.5% respectively. The cost of sunflower threshing is ₹ 5.30/kg as compared to ₹10.40/ kg with conventional method.

Solar assisted e-prime mover for weeding and spraying in soybean crop

A solar assisted e-prime mover was developed and its field performance in spraying and weeding (horizontal rotor) was conducted. The speed of operation for horizontal rotary weeding and spraying was 1.3 km/h and 2.6 km/h, respectively. The weeding efficiency, field capacity and power requirement for weeding was 70%, 0.06 ha/h and 550 W, respectively. Similarly, the field capacity and power requirement for boom sprayer was 0.52 ha/h and 50 W, respectively.

Total mixed ration (TMR) mixing machine for animal feed

Total mix ration machine was developed for mixing animal feed. For preparing TMR mixture 60% wheat straw and 40% concentrates were taken. The composition of the concentrate was mineral mixture 2%, de-oiled rice bran 30%, wheat/barley 35%, gram *churi* 17%, groundnut cake 15% and 1% salt. Capacity of TMR machine was 25 kg. Mixing time of 10 min was the best for obtaining uniform TMR mixture. Variation in feed nutritive value within the batch was less than 6%; hence, the ingredients are mixed uniformly.

Bio-methane generation from urea pre-treated baled paddy straw

A process for the bio-methanation of baled paddy straw was developed without the energy intensive operations (chopping, grinding, chemical/microbial pre-treatment, etc.). The process includes on-field pre-treatment of straw bales with urea solution followed by anaerobic digestion without any size reduction and separate pre-treatment. The urea treatment intervened to achieve the C:N ratio of substrate in the range of 20:1 to 30:1. The urea pre-treated straw bales was co-digested with cow dung in the proportion of 50:50 (wb). The dry matter of substrate maintained at 10% (db) by addition of water. The biogas production was 458 l/kg of total substrate (db) which is 11% higher than the chopped untreated paddy straw co-digested with cow dung.

CNG fuelled tractor for agriculture and haulage operation

Compressed natural gas (CNG) can substitute gasoline or diesel fuel fully or partially. A three-cylinder tractor diesel engine was modified to run using 100% CNG. The reduction in compression ratio was reduced and spark plugs were accurately placed. A CNG gas mixture was mounted on the carburettor to supply proper air-CNG mixture. The engine was successfully operated using 100% CNG under no-load condition. The CNG consumption in the field condition without load was recorded as 3.07 kg/h.

Torrefaction system of 200 kg biomass capacity

A pilot scale torrefaction system having 200 kg biomass capacity was developed. Torrefaction of biomass is needed for easier transport and longer storage as material becomes dry, brittle and hydrophobic due to this process. The unit is equipped with heating elements of 9 kW capacity and has provision for removal of torrefied biomaterial by tilting the reactor. Torrefaction experiments were carried out on paddy straw. The recovery varied from 90–98%.

Production of high porous carbon from pigeon pea

High porous carbon was prepared using pigeon pea stalk in two stage activation. In first step, the pigeon pea stalk was carbonized at 300–450°C in annular core biochar reactor. The carbonized pigeon pea was activated in second step under carbon dioxide environment at different temperatures. The maximum iodine value was 720. The total carbon in the produced activated carbon varied from 78–85%. The average activation energy of activated pigeon pea stalk was estimated as 84 kJ/mol.

Upgraded pyrolysis process for conversion of pine needle pyrolysis bio-oil into liquid bio-fuel

The upgraded pyrolysis process for conversion of pine needle pyrolysed bio-oil into liquid bio-fuel was developed. Pine needles are the residue of pine (*Pinus roxburghii*) forest and a major cause of forest fire in the North Western hills of India. Experiments were conducted to convert pine needles into bio-oil and biochar through catalytic pyrolysis process. The catalyst ZSM-5 and CaO were used with pine needles biomass in a ratio of 10, 20 and 30%. Process parameters such as pyrolysis temperature, gas flow rate, vapour cooling temperature, heating rate were optimized by using central composite design (CCD) in response surface methodology (RSM). A maximum 24% bio-oil was recovered under optimized condition for ZSM catalyst whereas 13% bio oil recovery was obtained with CaO.

Assessment of carbon fluxes in rainfed cotton ecosystem

An Eddy covariance flux tower along with a suite of meteorological sensors has been established at the experimental farm of ICAR-Central Institute of Cotton Research (ICAR-CICR), Nagpur, Maharashtra, India. CO_2 fluxes between the terrestrial rainfed cotton ecosystem in the Black Soil Region and the atmosphere was measured throughout the cotton season from mid June 2020 to last week of 2021. The peak Leaf Area Index of cotton at 110 days after sowing in the fields of the footprint area of the tower ranged from 2.29–3.14. During the crop season the cumulative Net Ecosystem Exchange (NEE) was negative with a value of –392 g C/m indicating that rainfed cotton was a sink for CO_2 to the extent of 3.9 tonnes/ha. Further the Ratio of cumulative Ecosystem Respiration (R eco)/ Gross Primary Productivity (GPP) was approximately 63%.

Pusa-farm sun fridge for storage of perishables

Pusa-Farm Sun Fridge (FSF)- an initial link in cold chain for perishables has the potential to benefit 90 million smallholder farmers in India, as these can be self-built by farmers from locally available materials and do not need electrical supply or batteries for cooling. The structure of size 3 m× 3 m × 3 m and 2 tonnes capacity uses 12 solar panels @ 415 W each, in series-parallel circuit, to power 1.5 tonnes refrigeration capacity. The innovative design features in the Pusa-FSF are water battery for night time cooling and a solar sensing system which can match the demand of the refrigeration system with the available sunlight successfully. Its mesh and

wetted-fabric walls with low cost styrofoam panels insulation keeps the structure cold through the combined effects of evaporative cooling and solar refrigeration. Pusa-FSF could achieve daytime temperatures as low as ~4–6°C and night time temperatures below 10°C, when the daily ambient maximum temperature reaches approximately 45°C. This facility offers smallholder farmers inexpensive access to cold storage even without electrical connection and improves their control over the marketing of their crops to fetch better prices.

Soil Moisture Indicator

ICAR-SBI team has developed a handy and user friendly electronic based Soil Moisture Indicator (SMI) to schedule irrigation for saving precious irrigation water. Evaluation of the SMI in participatory action research with farmers indicated that SMI is better than tensiometer. Farmers' experience showed that scheduling irrigations using SMI could save considerable quantity of irrigation water per ha per year in sugarcane crop without compromising yield. The team bagged First Prize in the National Water Awards-2019 for "Soil Moisture Indicator and its application in irrigation water management" in the Best Research/ Innovation/adaptation of New Technology for Water Conservation category by Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India.

Mechanized sett treatment for sugarcane

Team at ICAR-SBI, Coimbatore, Tamil Nadu has developed and validated mechanized delivery of fungicides through sett treatment device to manage red rot, smut and wilt effectively in sugarcane. Now sett treatment device has been upgraded with provision of heat treatment and its efficacy against grassy shoot and smut diseases was validated.

Predicting reference evapotranspiration

Machine learning a subset field of Artificial Intelligence (AI) was used for estimating atmospheric water demand in a semi arid region. Reference evapotranspiration is controlled by climatic factors; hence estimation of reference evaporation gives an idea about the atmospheric demand of the environment. Machine learning techniques like ELNET, KNN, MARS, PSLR, RF, SVM, XGBoost and Cubist were employed to predict daily reference evapotranspiration on weather parameters (2000–20) of Jhansi. All models performed well during calibration showing higher R^2 which ranges from 0.970 for PLSR model to 0.999 for cubist models. During validation of the entire machine learning models, coefficient of determination (R^2) ranges from 0.819 to 0.999, RMSE from 0.608 to 0.071 and MAE from 0.384 to 0.036. On the basis of statistical parameters, it has been found that cubist model (R^2=0.999, RMSE=0.071, MAE= 0.036) outperformed than all other models and can effectively simulate the prediction of reference evapotranspiration in semi-arid region. Artificial neural network (ANN) demonstrate capability to predict reference ET with high accuracy (R^2=0.97) using complete input data. Further, ANN was also tested with limited data set (Tmax, Tmin and Rn) with fair accuracy (R^2=0.89). This signifies that even in limited data scenario, machine learning models could be an effective tool (R^2 =0.89) to predict the reference evapotranspiration in semi-arid region.

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10. Post-harvest Management and Value-addition

Maize cob dryer

Maize cobs are generally harvested at around 35% (wb) moisture content while shelling operation is performed at around 17% moisture content (wb). At the time of harvesting, the environmental conditions of high temperature and relative humidity favour the growth of *Aspergillus flavus* and *Aspergillus parasiticus*, that produce mycotoxins. Its contamination decreases if cobs are dried soon after harvesting. A hot air maize cob dyer was developed with 150 kg capacity. The drying is carried out at 60°C, and it takes 24–27 h to reach the final moisture content of 17–18% (wb) at the atmospheric temperature (36.86°C) and RH (51.37%).

Oxygen concentrator

Ozone as a food disinfectant and fumigant during storage is being promoted as it does not leave any residue. Oxygen concentration facilitates better ozone generation hence an oxygen concentrator was developed. It utilizes a molecular sieve to adsorb gases onto zeolite minerals at high pressure.

Rapid testing kit for detection of aflatoxin B1 in agricultural produce

Certain fungi that are found in agricultural crops such as maize, peanuts, cotton seed, chillies etc. produce aflatoxins. These are carcinogenic and impose qualitative and quantitative losses to the agricultural produce. The lateral flow immuno assay (LFIA) device work with competitive ELISA principle is the first kind of lateral flow device developed for detection of toxins in the field of agriculture in India. The proud "Make in India" product comes with a very reasonable price, and can be used by any farmer/individual without any sophisticated equipment. The extraction takes about 20 min, and the test can be conducted within 10 min. The result can be interpreted by visual observation. The limit of detection was set to be 10 ppb, which is crucial for export of the produce to most of the countries.

Natural ventilator based modular onion storage system

A natural ventilator based modular onion storage system of one tonne capacity, was developed. During operation, ventilator takes the air inside the stored onions and pushes it out via the outer flexible blades. The exited air removes the respiratory heat generated by the stored onions. The removal of air creates pressure differential inside the storage structure. An Ultraviolet resistive polyethylene film covering is provided to protect the stored onion from high humidity and splash of rain water. The storage study of the onions for 4 months during May to August 2020 indicated 18% physiological weight loss, 5.5% rotting and 0.2% sprouting losses of stored onions.

De-bunching tool for medicinal root crops

The roots of medicinal crops like Safed Musli, Shatavari, Sarpaghandha are in the form of bunch with one end attached together. A manual de-bunching tool was developed. Its de-bunching capacity for Safed musli was 10.3 kg/h as compared to 7.5 kg/h for de-bunching manually. The tool increases de-bunching capacity by 2.8 kg/h and reduces material loss by 4% over traditional practice.

Peeling machine for medicinal root crops

A peeling machine was developed for medicinal root crops. There is also provision of water spray for washing roots before and during peeling of material. The developed machine was tested for Safed musli roots. The peeling efficiency for Safed musli was observed to be 92% in double pass. Washing of roots takes place simultaneously with peeling to remove out the peeled off material. The capacity of machine for Safed musli peeling is 15–20 kg/h. The machine has potential to mechanize peeling operation of medicinal root crops and to reduce drudgery, labour cost and time.

Power operated baby corn dehusker

A power operated baby corn dehusker was developed to reduce the drudgery in dehusking of baby corn. The slitting section and dehusking cum desilking section are operated by 0.5 hp and 1.0 hp electric motors, respectively. It has capacity of 25 kg/h. Slitting efficiency, dehusking efficiency and desilking efficiency of this

IoT-based smart storage structure for pulses

IoT-based smart storage structure for pulses was developed for one-tonne storage bin, based on the developed protocol. It includes three sensor modules and each module has a carbon dioxide sensor, temperature and RH sensor, and a display unit. One module has an oxygen sensor also. These sensor modules are positioned at three depths of one-tonne storage bin for monitoring and measurement of different parameters. The supply of CO_2 is regulated by a control panel.

machine are 100, 92 and 100%, respectively.

Manual grader for multiplier onion

The developed manual grader for multiplier onion consists of feed inlet, perforated drum, handle, shaft with bearing, collecting tray and supporting frame. The length and width of the feed inlet are 350 and 50 mm, respectively. The capacity of grader is 200 kg/h with a grading efficiency of about 93%. The cost of operation of the grader is ₹ 0.4/kg and results in saving of about 35% compared to manual grading.

Banana pseudostem outer sheath plate making equipment

The equipment consists of male and female die made of aluminum of size 200 mm, 250 mm and 300 mm. Provision was given to vary the temperature and pressure based on the raw material and requirement of the finished product. The process of joining the outer sheath to make for plate of required size was also standardized. The average capacity of the equipment is about 30–40 plates/h.

Low-cost energy efficient cotton stalk briquette based crematorium

An innovative low-cost energy efficient biomass briquette-based crematorium, which allows performing of all traditional rites during cremation, was developed. It requires about 35–40% less fuel as compared to traditional wood-based crematorium.

Digital ginning percentage indicator (DGPI)

Traditionally seed cotton is traded irrespective of Ginning percentage (GP) due to lack of appropriate machine to record GP accurately on real time basis in market yards and ginneries which deprives farmers from getting additional benefit for sowing improved GP cotton cultivars. Hence to facilitate objective grading based on GP and to promote lint based trading, a digital ginning percentage indicator (DGPI) for portable cotton gin was developed on electromechanical principal for real time determination of GP of seed cotton.

Reusable face mask with breathability and antimicrobial Property

A three layered cotton fabric based mask was developed, which provided required breathability to the wearer along with antimicrobial and water repellent characteristics. The top and bottom layers of the mask were made up of fluorine free water repellent treated polyester-cotton blended fabric which provided water repellent and quick drying properties to the mask. The middle layer of the mask was made up of 100% cotton fabric treated with institute developed non-leaching type antimicrobial agent. The breathability of the developed mask was 37 $ft^3/min/ft^2$. The differential pressure is 46 Pa/cm^2. The bacteria filtration efficiency is 78% when tested under dynamic conditions and the antimicrobial efficiency is 100% against both gram positive and negative bacteria. The durability of the antimicrobial finish is up to 25 washes. The particle filtration efficiency of the developed mask is 58%. The mask will provide higher level safety and comfort to the wearer.

Heat generating smart textiles products for cold climates

Composite yarns prepared by wrapping conductive carbon filaments with cotton fibres through friction spinning were used to develop flexible heat generating pads for multiple applications. These include heating shoe pads, thermal garments, warming seat covers, heating gloves etc. which can be operated by 5V, 2A DC power supply. A controller was provided to vary the heating rate of these pads to generate the temperature (40 to 80°C) as per the user requirement. A mobile rechargeable power bank (10Ah) can be used in place of DC current to provide the warmth for 7–8 h with single charge. A MoU was signed for transfer of technology for thermal seat covers for automotive applications.

Jute fibre grading system

Modified Jute Fibre Grading System was developed, in which the grades were reduced to five grades (TD-1 to TD-5) from existing eight grading system (TD-1 to TD-8). The modified grading system was approved by BIS as Fifth Revision (IS 271:2020). The grading system consists of five parameters Strength, Root Content, Defects, Fineness and Colour. For instrumental determination of various characteristics like strength, defects, root content, fineness, etc. reference to the relevant part of IS 7032 will be followed, where value of the corresponding parameters, mentioned in Instrumental Method was optimized using the standard instruments developed by ICAR-NINFET (erstwhile NIRJAFT). Classification of raw jute grading was approved for two cultivars i.e. WHITE jute namely, W-1, W-2, W-3, W-4, and W-5; TOSSA and DAISEE jute namely, TD-l, TD-2, TD-3, TD-4, and TD-5. Commission for Agricultural Cost & Price (CACP), Government of India adopted five grading system for fixing minimum support price (MSP) of jute and mesta.

Process/Products

ACE-inhibitory peptides from fish waste

Angiotensin-1 Converting Enzyme (ACE) inhibitors control hypertension, one of the cardiovascular diseases killing people silently every year worldwide and is spreading at an alarming rate in India. Pharmaceutical ACE-inhibitory drugs, used to treat hypertension possess drug-associated side-effects like cough, angioedema, chest pain etc., therefore, attempts were made to identify the bioactive peptides having potential therapeutic benefits.ICAR-CIPHET utilized the rohu fish waste (head, fins, scales and swim bladder; 0.9 million tonnes per annum in India) for the extraction of ACE-inhibitory peptides, a high-value nutraceutical product. Extracted peptides showed 55% ACE- inhibition.

Registered trademark of ICAR-NINFET

ICAR-National Institute of Natural Fibre Engineering and Technology has successfully registered two Trademarks "NINFET-*Sathi*" against TM application no. 4259315 applied under class 1 and TM application no. 4259316 under class 42 with Trademark number 4259315 (Certificate No.2385860 dated 07/08/2019) and Trademark number 4259316 (Certificate No.2385861 dated 07/08/2019) respectively.

Trade Mark Class 1: Any kind of Chemicals that are used in Industries, science or photography, even chemicals used in agriculture, horticulture and forestry, also the adhesives used in Industry, unprocessed plastics, chemical substances involved inedible substances.

Trade Mark Class 42: Technological and scientific services; industrial analysis and research services; development of computer hardware and software and their designing.

Trademarks registered in the name of ICAR-National Institute of Natural Fibre Engineering and Technology in the Trade Marks Registry of Government of India, Mumbai were commercialized for Accelerated Retting Technology.

Grass pea (*Khesari*) flour based muffins

The consumption of grass pea (*Khesari*) flour is limited in different food applications because of presence of undesirable compound β-N-oxalyl-L-α, β-diaminopropionic acid (ODAP). Protein enriched muffins were developed from grass pea flour. The optimized product has hardness of 1.84 kg, springiness of 0.95, instrumental brightness of 70.52 compared to values of 1.49, 0.96 and 77.42 for wheat flour based reference muffin samples. The mean overall acceptability score of 8.30 is observed in comparison to 8.67 of the reference sample.

Jute leaf tea: A health supplement

Institute has validated a technology for preparation of jute leaf drink formulation through an external project endorsed by Ministry of Textiles, Government of India. A protocol for harvesting of jute leaves was developed and a rural based solar drying system was also optimized. The jute leaf tea are rich in antioxidant components and prove to be an efficient health supplement.

Antioxidant agent	Range
DPPH	51–94 (IC 50 µg/ml)
TPC	8–50 (GAE/g DW)
FRAP	1.25–2.5 (mmol Fe^{2+}/g)

Wheat gluten based soft nutri-cereal atta

Nutri-cereals such as bajra and maize are highly nutritious and are even superior to rice and wheat in various nutritional constituents like iron, zinc, niacin, magnesium, phosphorus, manganese, potassium and vitamins A, B complex etc. They contain high amounts of protein, fibre, essential amino acids like methionine, threonine and tryptophan. Due to the high content of nutrients, these non-conventional grains have health promoting effects equal to or even in higher amount than fruits and vegetables and have a protective effect against diabetes, heart disease, obesity, blood pressure and atherosclerosis. In spite of all these benefits, bajra and maize occupy a lower position in human food chain in comparison to staple food grains and are not popular among consumers due to lack of good dough making quality, which limits their application in routine bakery products and in chapatti making. To address this problem, Indian Agricultural Research Institute, New Delhi has developed a technology of vital wheat gluten (VWG) reconstitution in bajra and makka flour and developed products such as Hallur: Soft Bajra Atta and Makai: Soft Makka Atta as good as wheat for superior dough quality. Hallur: Soft Bajra Atta is designed to solve this problem by extracting vital wheat gluten (VWG) protein from wheat flour and regenerating it with bajra flour to improve viscoelastic properties for superior dough and chapatti making quality as good as wheat. The different proportion of VWG regeneration was optimized in bajra flour and tested for several dough quality parameters. The 7–10% VWG was optimized for bajra flour, depending on the purity and water absorption capacity of the extracted VWG. Similarly, dough consistency is the major problem addressed in the product Makai: Soft Makka Atta. A technology of starch gelatinization was exploited in VWG reconstituted makka flour and different percentage of VWG were optimized and further tested for dough quality parameters to make it as superior as wheat flour. Here 5 to 10% VWG reconstitution depends on the quality of extracted VWG. Both Hallur: Soft Bajra Atta and Makai: Soft Makka Atta, with all the bestowed nutrition, can now be consumed with variety of recipes. The superior dough quality of these products has the potential to move as a sustainable daily diet to have paradigm shift from calorie rich plate to nutrient dense consumer plate without altering their preference. This product not only can positively affect throughout local markets, supermarkets and e-Commerce sites but also has the potential to address nutritional challenges, as the hidden hunger and malnutrition are linked with the huge investment from the Indian government with the estimated economic cost of 0.8 to 2.5% of the total GDP, which is equivalent to $15–46 billion. Superior nutritional composition of bajra and makka with improved dough quality as good as wheat will boost their consumption, and also enable the farmers to have incentive to grow more nutri cereals.

Safflower protein concentrates, isolates and hydrolysates

Efficacy of safflower protein concentrates, isolates and hydrolysates was tested in diets of Wister rats. Gradual increase in the feed intake was observed in all the treatments. Rats (both male and female) fed with safflower protein concentrate (SPC), safflower protein isolate (SPI) and safflower protein hydrolysate (SPH) showed significant increase in the body weight. However, higher increase was recorded with SPH diets. Biochemical parameters such as glucose, total cholesterol, triglycerides, HDL, LDL, total protein,

albumin, bilirubin, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, creatinine, urea, uric acid, phosphorus, calcium and CPK were also recorded. All biochemical parameters were in normal range. All body composition and urine parameters were in normal range. Diet did not show any differences/ abnormalities in reproductive performance and histopathological parameters.

Dairy

- Strip based technology for early detection of sub-clinical and clinical mastitis within 30 min was developed.
- Spore based technology was developed for rapid detection of antibiotic groups in Aqua-products.
- Lateral flow assay-based method was developed for rapid detection of presence of buffalo milk in cow milk.
- Spore based strip was developed for rapid detection of β-lactam antibiotics in milk, which works on the induction of β-lactamase enzyme in germinating bacillus spores.
- A PANI-PEC paper strip sensor was developed for the detection of total bacterial count in raw and pasteurized milk with a detection limit of 4 log cfu/ml within 4½ h at 37°C.
- Paper strip-based sensor for detection of heavy metals in milk was developed.
- Metagenome and metabolome profiling of milk from indigenous (Gir, Sahiwal and Tharparkar) and crossbred (Karan Fries) cattle revealed high microbial diversity, and metabolic fingerprints were unique to the breeds.
- RP-HPLC profile of peptides derived following *in vitro* gastrointestinal digestion of skim milk indicated no significant difference on digestion behaviour among different indigenous breeds of cattle (Sahiwal, Tharparkar and Gir).
- A wash RM- protocol was standardized for the detection of RM-adjustor in ghee with detection limit of 1%.
- A fluorescence spectroscopy-based method was standardized to evaluate heat induced interactions between milk proteins in high protein dispersions.
- Non-targeted GC-MS method was optimized for identification of potential migrants from milk and ghee packaging polymers.
- A movable and stand alone electrochemical sensing system for automation of CIP in dairy plants was developed.
- A technology was developed for production of finger millet incorporated ready to use high protein (16% protein + 2% fibre**)** composite dairy spread with a shelf life of 10 days at refrigerated condition.
- Lactobacillus fermentum NCDC 400 incorporated synbiotic dairy product exhibited antioxidant, anti-obesity and the hepato-protective properties.
- A process was optimized for the preparation of a naturally carbonated whey based probiotic drink using a co-culture of dairy yeast *Kluyveromyces lactis* NCDC 257 and indigenous probiotic strain *Lactobacillus plantarum* MTCC 5690.
- A process for the manufacture of high milk protein powder for formulation of Sandesh was optimized.
- Developed the manufacturing protocols for products such as Bhapa (Steamed) Sandesh, Probiotic Ricotta cheese from buffalo milk, goat milk based functional beverage, processed cheese from ultrafiltration retentate, gluten free multigrain vermicelli kheer and its instant mix etc.
- Carotenoids from carrot bio-waste extracted for food application, using green solvent.
- On-package freshness indicator developed for milk-millet complementary food.
- On-package colorimetric freshness indicator developed for sandesh.
- Technology of ripened cheese developed from camel milk for the first time.

Camel

Turmeric fortified camel milk, fresh and pasteurized camel milk, and a new product camel milk chocolate (Cocoa) kulfi are available.

Yak

Mozzarella: A fresh soft un-ripened cheese was made from fresh yak milk. It also has a great appeal among people who are interested in trying yak milk products but has reservations due to its characteristic odour of traditional matured yak milk products.

Ripened yak cheese: Ripened yak cheese, a semi hard cheese, was developed. It is off-white in colour and has a characteristic sharp flavour. This cheese will be an addition to the wide variety of cheeses of the world and has a great potential for commercialization owing to its characteristic taste, flavor, texture and ease of storage and transportation.

Mithun

Milk profile: Milk of mithun contains saturated 69.08% and unsaturated fatty acids 30.82%. The concentration of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) was 28.97 and 1.85% of the total fatty acids, respectively. Palmitic (C16:0), oleic (9-cis C18:1), stearic (C18:0) and myristic (C14:0) acid contributed the most to total FAs. The

Scope of NABL laboratory extended

ICAR-NRC on Meat has established NABL accredited laboratory for Meat Species identification as per ISO/ IEC 17025:2017 (Lab No. TC-7992). Its scope was extended to encompass: molecular biomarker analysis (DNA) for animal species identification and wildlife meat species identification, and Halal compliance through detection of porcine DNA in meat and meat products.

comparison of the mithun milk fatty acid indicated saturated fatty acids values were higher than cattle but lower than buffalo milk and oleic acids values were almost similar to cattle but lower than buffalo. Moreover, complete mithun milk profiling revealed the presence of a higher amount of amino acids (esp. lysine), fat-soluble vitamins (vitamin A, D, E) and minerals such as calcium and magnesium in comparison with other livestock species (cattle, buffalo).

Egg

Egg rabrimalai: Nutritious Egg rabrimalai prepared with whole egg and milk. The process involved formulation of sweet spongy egg balls along with milk which were then dipped in thick milk slurry. The product is rich source of protein with good amount of calcium, minerals without addition of fat source. The shelf life is one week at refrigeration temperature (4±1°C).

Multi-grain egg biscuits: A processing technology was standardized for formulation of multi-grain egg biscuits with main ingredients like whole egg, oat flour, ragi flour, whole wheat flour, all-purpose flour, skimmed milk powder, sugar) and other ingredients. This can be adopted even in rural set-up. The main features of the formulated egg biscuits are high in protein and fibre, low fat contents and calcium and phosphorus, with low in moisture content, also having shelf life more than 3 weeks at ambient temperature (30°C) in air tight PET jar.

Meat

Pork products: Functional pork products with health benefits (PUFA enhanced, fibre enriched, antioxidant rich, low salt and low fat/ low calorie) were developed and simple yet viable processes were standardized to incorporate the locally available medicinal plant parts (leaves/ fruits/ buds etc.) in the pork product's formulations. These materials were found to have positive effect on preventing microbial spoilage and fatty acid oxidation during the storage period. Scientific interventions were introduced in the packaging of pork and pork products to improve the brand value of the products during marketing.

Kit for species identification of pork: Gold-nanoparticle-based, sandwich-format lateral flow immunoassay (LFIA) test kit was developed for point-of-care test for species identification of pork. The kit allowed the detection of as low as 0.5% (w/w) pork in raw and heat-processed meat mix, and commercial meat samples within 15 min including sample preparation.

Meat composition of Kadaknath chicken: Feeding of the dried Moringa leaf powder (MOLP) to day – old to marketing age (17th week) Kadaknath chickens resulted in higher content of intramuscular fat with more favorable proportions of unsaturated fatty acids, including n-3 acids, and decreased level of saturated fatty acids. It also improve sensory properties.

Portable meat production and retailing facility (P-MART): To promote hygienic meat production, Portable Meat Production and Retailing Facility (P-MART) was developed. Patent application was submitted for protection of Intellectual Property (Patent Application No. 202111016135). The technology was transferred to private entrepreneur.

Wool

Quilt from coarse wool: Carding machine output padding web's areal density was optimized in the range of 250 to 450 gsm depending upon the end use requirements. Prepared quilt comforter was subjectively assessed for aesthetics, softness, smoothness, warmth and breathability, and found to have mean values of 3.5 to 4.5 (0–5 scale). Thermal insulation and warm/cool feeling were assessed in the range of 0.234 to 0.300 m^2 K/W and 0.13 to 0.16 W/cm^2, respectively.

Composites from coarse wool: Different type of composite samples were prepared with resin to fabric ratio (60/40) by hand lay-up technique using coarse wool from Malpura and Deccani sheep. Maharashtra Deccani wool composite showed highest tensile strength (34 MPa) while Malpura wool composite registered least tensile strength (25 MPa) and attributed to the differences in the areal density of various non-wovens. A good adhesion was found between Maharashtra non-woven and epoxy resin which is responsible for less void present in the material, eventually resulting in high strength.

Fisheries

Designed V-form double-slotted otter board: Designed and fabricated the prototype of

Fucoidan from brown seaweeds

ICAR-CIFT has developed an extraction protocol based on "Green Chemistry" principles for fucoidan from brown seaweeds. A novel microencapsulated formulation of Fucoidan, a molecule with proven anticancer, anti-inflammatory, and antioxidant activities, was developed which showed promising application in heart health promotion in preclinical trials.The technology of fucidon extraction from seaweed and the nutraceutical formulation has been transferred to Bodina Natural Pvt Ltd and the commercial production started under the trade name Zafora.

Edible and functional seaweed-based sachet

Standardized a technology for preparation of edible and functional seaweed sachet using red seaweed-*Kappaphycusal varezii* and green seaweed-*Ulva* sp. The seaweed-based functional and edible film has good sealing, antioxidant properties and very good physical and mechanical properties. It can be used to pack taste-maker for noodles and soup powder etc.

Liquid fish fertilizer

Technology for fish soluble-based growth promoter was developed and transferred to M/s 7SEAS Ventures, Udupi, Karnataka. The Company has launched the product under the brand name "7Seas Agro" (Liquid fish fertilizer as growth promoter and natural source of nitrogen).

V-form double-slotted otter board of size 1500 mm × 900 mm and weight 120 kg each. Comparative trials with the conventional V-form otter boards (without slots) of the same size and weight showed trawling at reduced engine rpm and reduced fuel consumption (approximately 2–3 l/h).

Designed and developed FRP pedal boat: To reduce the use of fossil fuel in inland fishing vessels and to minimise the pollution issues, a 3 m FRP pedal boat design was developed and constructed. This boat requires no fuel and has zero carbon emission. A light weight foldable type canopy is fixed on top for protection from rain/sun.

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11.

Agricultural Human Resource Development

The Indian Council of Agricultural Research (ICAR), to keep pace with the agricultural growth, has been playing a leadership role towards building and nurturing future ready agricultural graduates and skilled human resources, equipped with research as well as entrepreneurial acumen. High priority is accorded to upgrade quality of higher agricultural education in State Agricultural Universities (63 SAUs), Deemed-to-be-Universities (44 DUs) and Central Universities (4 CUs) with Agricultural faculties under the National Agricultural Research System (NARES) and Central Agricultural Universities (3 CAUs). The Division through the implementation of scheme-Strengthening and Development of Higher Agricultural Education in India, assists the Agricultural Universities (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 rigorous accreditation and ranking process. The scheme also enabled these institutions in building excellence in specific strategic areas in education and research as well as capacity building through Niche Area of Excellence (NAE), promoting holistic higher agricultural education by blending knowledge and skill through Experiential Learning Models thereby promoting entrepreneurial capabilities of students.

The National Agricultural Education and Research System (NARES) is one of the largest institutions in the world. The effective functioning of this system in close association with education and extension has contributed towards the rapid growth of agriculture in the country. The present system comprises essentially of two main streams, viz. Indian Council of Agricultural Research (ICAR) at the National level and agricultural universities at the state level, besides other organizations involved in agriculture and allied activities. Capability of people to be effective and productive economic agents, i.e. human capital, is the most important component for rapid development in agriculture and allied sciences. The education and skills of agricultural people are significant factors in enhancing every aspect of agricultural performance.

Governance and quality assurance

Accreditation of Agricultural Universities: To address the concerns of quality higher agricultural education, the National Agricultural Education Accreditation Board (NAEAB) was established to advise the Council in evolving norms and standards for accreditation of institutions and programmes of agricultural education. Online portal for submitting documents for accreditation was developed (accreditation.icar.gov.in).

The NAEAB has implemented online mode and uploading LoI/IEA/Statement of Compliance, and its preliminary examination is now online through portal. Currently, 62 Agricultural Universities and 19 private agricultural colleges are accredited.

Ranking of Agricultural Universities: The ranking of Agricultural Universities was initiated by ICAR to drive the universities towards improving quality standards and enhance their visibility. The ranking status allows the students to make informed choices for university placement, and further, helps the universities, to self-assess themselves on the quality and enhance their abilities. The emphasis on parameters such as teaching resources and outcome, faculty profile, students' performance, research productivity, research impact, research excellence, extension activities, outreach programmes, revenue generation and peer recognition of the faculty, students and staff of the university, etc., are considered while evaluating the agricultural universities.

So far, the ranking has been done for the last three years based on the information received from the universities in the prescribed proforma through hard copies. In view of the COVID19 pandemic situation, the required information is being obtained online from the universities. Accordingly, an Agricultural University Ranking System (AURS) was developed to enable the submission of the required data by the universities and the evaluation/verification by the Committee online. During 2020–21, first position was bagged by the NDRI, Karnal, followed by PAU, Ludhiana and IARI, New Delhi, for the second and third positions, respectively.

Broad Subject Matter Area (BSMA) Committees: A National Core Group was constituted by ICAR for development of Academic Regulations for Masters and Ph.D. programmes, defining names and curricula of Masters' and Ph.D. disciplines for uniformity and revision of syllabi for courses of Masters' and Ph.D. degree disciplines. On the recommendations of the members of National Core Group, 19 Broad Subject Matter Area (BSMA) Committees were constituted for revising the syllabus. These committees conducted several meetings with the concerned experts and stakeholders and developed the syllabus for their respective subjects. While developing the syllabi, various provisions of National Education Policy-2020 were also considered and complied to provide quality higher education and to develop good, thoughtful, well-rounded, and creative individuals.

Necessary provisions have been made in the curricula to enable an individual to study major and minor specialized areas of interest at a deep level, and also develop intellectual curiosity, scientific temper and creativity.

The revised curricula for 79 disciplines were designed to improve the existing syllabus and to make it more contextual and pertinent to cater the needs of students in terms of global competitiveness and employability. To mitigate the concerns related to agriculture education system in India and to ensure uniform system of education, several changes were incorporated in common academic regulations in relation to credit load requirement and its distribution, system of examination, internship during Masters programme, provision to enrol for online courses and take the advantage of e-resources through e-learning and teaching assistantship for Ph.D. scholars.

Student READY: The program is offered to undergraduate students during the final year of the course. The programme helps to reorient graduates of agriculture and allied subjects to develop entrepreneurs in emerging areas. During the last one year 17,205 students were supported with stipend under RAWE program.

During the year, Student READY monitoring system, including Experiential Learning was launched. This is an online monitoring system for the Student READY programme launched with the technical support from the ICAR-IASRI, and hosted on Agricultural Education Portal (https://education.icar.gov.in/). The online programme was developed to record all the activities and achievements of the various components of the Student READY programme, viz. Experiential Learning-Business Mode, Experiential Learning-Hands on Training (Skill Development), Rural Awareness Work Experience (RAWE), In Plant Training/ Industrial attachment/Internship and students projects. All the agricultural universities shall be submitting the relevant data in the portal.

New Education Policy (NEP-2020) implementation strategy for ICAR led Agricultural Education System

NEP, launched by MoE-GoI proposed several changes in the education system of India, including higher agricultural education system. These changes include – transforming the institutional structure as new form of multi-disciplinary Higher Education Institutions (HEIs), course curricula, academic structure of degrees/diplomas/ certificate system, introduction of credit banking system, partnerships among universities, industry and other stakeholders. A national level Committee was constituted by the ICAR to develop an implementation strategy to comply with various provisions of National Education Policy-2020 (NEP-2020). Based on the principles and philosophy of NEP-2020, a roadmap was prepared to comply with various provisions of NEP-2020.

Human Resource Development

Teaching, Research and Capacity building

Niche Area of Excellence: The NAE programmes are being supported in the important focussed areas, viz. assessment of heavy metals in crop plants, enhancement of shelf life of pearl millet flour, development of nanomaterial for tissue regeneration in animals, disease management in plants and in bio-pesticides, etc. for building excellence in specific strategic areas in agricultural education and research, and capacity building.

Significant achievements

- Lactic acid bacteria from human milk and goat milk origin indicated a high frequency of resistance to aminoglycosides, betalectum, glycoproteins, cephalosporin, quinolones, macrolides, etc.
- The protocols for isolation/culture/ characterization of stem cells from different species of animals were standardized and successfully applied for bone healing in animals.
- Organic poultry production complex with an area of about 0.50 ha was developed following NPOP standards for organic poultry farming. The area has indoor and open space to maintain about 1,000 birds under strict organic management system as per norms. The supplementation of 5% *Azolla* leaf powder and 5% *Moringa* leaf powder in the diet was beneficial for growth and egg production, under organic poultry system.
- An efficient processing technology – called "hydro treatment (HT)-hydro thermal (HTh) and thermal near infrared rays (thNIR)" successive treatment was developed and achieved significant reduction of rancidity in HT-HTh-thNIR treated flour even after 90 days of storage at room temperature.
- Developed a Lab scale decorticator with different degree of decortication efficiency.

Pearl millet decorticator developed having different degree of decortication from 2–20%

- Ready to cook kodo millet pasta, beetroot enriched kodo millet pasta, brown top millet laddu, instant barnyard millet dosa and idli mix, proso millet chakli, barnyard millet custard powder mix, proso millet *dosa* mix drumstick leaves enriched, were developed, and were approved for commercialization and advertised for commercialization.
- Chemical composition of ten essential oils namely, *Brassica juncea*, *Citrus sinensis*, *Myrtus communis*, *Eucaplytus citriodora*, *Melaleuca alternifolia*,

Acorus calamus, *Commiphora myrrha*, *Cymbopogon nardus*, *Pogostemon cablin* was analysed, and evaluated against juveniles of *M. incognita*, which revealed strong action of *Brassica* essential oil with LC_{50} and LC_{90}, 0.20 and 1.92 µg m/L, respectively, after 24 h. Further molecular docking and simulation studies of the major constituent (allyl isothiocyanate) of *Brassica* essential oil showed π-cation of electrostatic interaction, π-donor H bonding and π-sulfur bonding between AITC and TRP391. Penetration of Oil Red O-EO blend in *M. incognita* and SEM imaging confirmed that the oil readily entered the nematode body through lipid layer of the cell wall and asserted its effect.

- Simultaneous optimization of extraction condition, for extraction of neem oil followed by Azadirachtin-A, was done using RSM using Box Behnken method. Under optimized condition, maximum yield of neem oil was 31.2% and 0.19% from neem seed kernel.
- The putative lipase gene from pearl millet cv. Pusa 1201 was identified and LOX enzyme was found as the major contributor for rancidity development in pearl millet flour.
- 1,876 paired grid based (1.47×1.47 km^2) soil (0–15 cm) and plant samples with GPS coordinates were collected covering 22 basmati rice growing districts of Uttar Pradesh, viz. GB Nagar, Ghaziabad, Eta, Etawah, Hathras, Mainpuri, Firozabad, Mathura, Agra, Bulandshahr, Kannauj, Farukhabad, Auraiya, Sahajanpur, Muzaffarnagar, Bagpat, Saharanpur, Meerut, Bijnor, Badaun, Bareilly, Pilibhit. In addition, 1,000 irrigation water samples were also collected across these districts for analysis of metals and metalloids.

The NAE centres organized 32 training programmes/ awareness workshops/ camps leading to capacity building of 52 faculty and 851 farmers and 182 students. Twenty-five PG students completed degree programme and 42 students are continuing research work and pursuing degree utilizing the facilities developed under NAE programmes.These centres published 30 papers in peer reviewed journals, including papers in journals assigned NAAS rating of 7 and above. Total revenue of ₹ 50.00 lakh was generated during the year. Five patents were filed by the NAE centres, and five technologies/ methodologies were developed, which are under process for commercialization. One of the technologies for the development of "wheat gluten based soft nutri cereal Atta bajra" with improved chapatti making quality (FSSAI Lic No. 10017011004518) was commercialised.

Attracting talent

All-India entrance examination for admission to UG: The 26th Undergraduate Examination for admission to 15% seats (100% seats at ICAR-NDRI, Karnal; 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 144,848 applications, out of which 122,993 candidates (85%) appeared. Of these, the number of female candidates was higher (62,239) than the males (60,752) indicating more number of girl candidates are getting attracted towards higher agricultural education. Among the categories, OBC (NCL) candidates were highest (54,875) followed by General (33,254), SC (16,018), General EWS (10,417) and ST (8,420).

All-India entrance examination for admission to PG: The online examination 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 20,811 candidates appeared in the examination (91%) out of 22,912 applicants. Of these, the number of female candidates (10,215) was almost equal to the males (10,595). Among the categories, OBC (NCL) candidates were highest (7,970) followed by General (5,786), SC (3,604), ST (2,026) and General EWS (1,425).

All-India competitive examination for Ph.D. admission and award of Junior/Senior Research Fellowship: The examination was held for admission to 25% seats (100% seats of Dr RPCAU,Pusa and ICAR-DUs) in Ph.D. programmes including award of ICAR-JRF/SRF (Ph.D.). A total of 8,919 candidates appeared (89%) in the examination out of 10,046 applicants. Of these, the number of female candidates (4,703) was higher than that of males (4,215). Among the categories, OBC (NCL) candidates were highest (3,027) followed by General (2,906), SC (1,555), ST (748) and General EWS (683).

Award of fellowships

- **ICAR fellowships for post-graduate students**: 599 and 298 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, 91 meritorious under-graduate students belonging to below poverty line families were awarded the scholarship.
- **Internship Allowance** to 4,248 veterinary graduates trained by Agricultural/ Veterinary Universities was provided.
- **National Talent Scholarship (NTS):** During the year 7,790 UG and 5,008 PG students were provided NTS.
- The ICAR Post-Doctoral Fellowship (ICAR-PDF) is a new programme initiated to identify and support motivated young researchers for conducting research in frontier areas of agriculture and allied sciences to build the national capacity. It provides them a platform to develop as an independent researcher capable of initiating a new programme in nationally important priority areas under the supervision of a mentor. Against the

approved slots of 25 PDFs, 12 are in position (ten in ICAR-IARI Pusa, New Delhi and two in ICAR-NDRI Karnal).

Globalization of agricultural education

Netaji Subhas-ICAR International Fellowships: A scheme on "Netaji Subhas - ICAR International Fellowships" for pursuing doctoral degree in agriculture and allied sciences in the priority research areas, to the (i) Indian candidates for studying 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 is operational. 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 206 candidates selected (during 2009–10 to 2020–21), 108 candidates have completed their Ph.D. under this programme. Ninety-one (91) candidates including 12 foreign national candidates are currently doing Ph.D. in their identified universities. Six candidates have joined their host universities abroad during the period. This year, online applications were invited and portal for the award of fellowships was created and linked with the Education Portal.

Globalization of Agricultural Education

India-Africa Fellowship Programme: India Africa Forum Summit III has been implemented from session 2017–18 with allotment of 500 seats (375 PG and 125 Ph.D.) for African nationals under Special Agricultural Scholarship. A total of 114 African nationals (87 PG; 27 Ph.D.) from 17 countries were enrolled successfully in 33 Indian Agricultural Universities/ CAU/Deemed Universities. Twenty African candidates (16 PG; 04 Ph.D.) from 16 countries joined the programme during session 2019–20. In continuation, IAFS-IV was scheduled to take place during the third quarter of 2020. However, due to COVID-19 pandemic and African Union, own prior engagement, the Summit was postponed for 2021. Due to postponement of the Summit, the approval of Cabinet has not been solicited so far for continuation of the scheme beyond 2020 and hence, Ministry did not consider any new admissions for the year 2020–21.

India-Afghanistan Fellowship Programme: India Afghanistan Fellowship Programme was approved till the academic year 2020–21. At the inception of the programme in 2010–11, the total available slots were for 614 fellowships. Currently, 482 Afghan nationals are enrolled in 51 Indian Agricultural Universities. During academic year 2019–20, a total of 82 Afghan nationals were enrolled for attaining higher education in Agriculture and allied sciences in identified Indian Agricultural Universities (AUs). No Afghan student was recommended in session 2020–21 due to the pandemic.

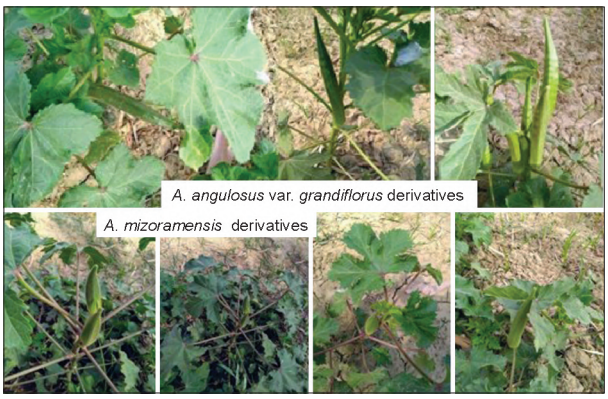
Promotion of excellence

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, 3 National Professors were in position. During the period under report, 18 National Fellows were in position.

The aim of Emeritus Scientist (53) and Emeritus Professor (45) 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.

Salient research achievements

- Effect of high hydrostatic pressure processing on textural and nutritional behaviour of minimally processed fruits and vegetables, was studied and the process optimisation done for vacuum impregnated ripe jackfruit and pineapple. The optimal process parameters for vacuum impregnated ripe jackfruit is 10.0 kPa pressure, process temperature of 50°C for 40 min and a vacuum relaxation time of 5 min. Likewise, vacuum impregnation at 10.2 kPa pressure and 50°C for 22 min holding was the best combination for pineapple.
- Diversity in 17 wild species of okra was screened for identification of sources of tolerance to the major viral diseases, namely, OYVMV and OELCV affecting cultivated okra; and five species with high degree of tolerance were identified. Crosses of cultivated okra varieties with these tolerant species, *A. angulosus* var. *grandiflorus*, *A. tetraphyllus*, *A. enbepeegearense*, *A. pungens* var. *mizoramensiss* sp. nov. (Mizoram) and *A. moschatus* were done and the derivatives in F_5



Segregating populations of the interspecific crosses

and Back Cross generations were generated. Field screening of selections indicated successful transfer of tolerance trait in the cultivated okra background. The material generated (127 selections) was deposited with NBPGR for accessing and use in variety improvement programmes. These are all new sources of tolerance genes except *A. tetraphyllus*, hence novel for wider deployment into okra cultivars.

- Patent granted on Alternate Energy Light Trap for monitoring incidence of major rice pests such as BPH, WBPH, YSB, etc. in field condition. High BPH-resistant and multiple resistant genotype CR2711-76 (Tapaswini × Dhobanumberi) was recommended by the variety release committee,

Alternate Energy Light Trap

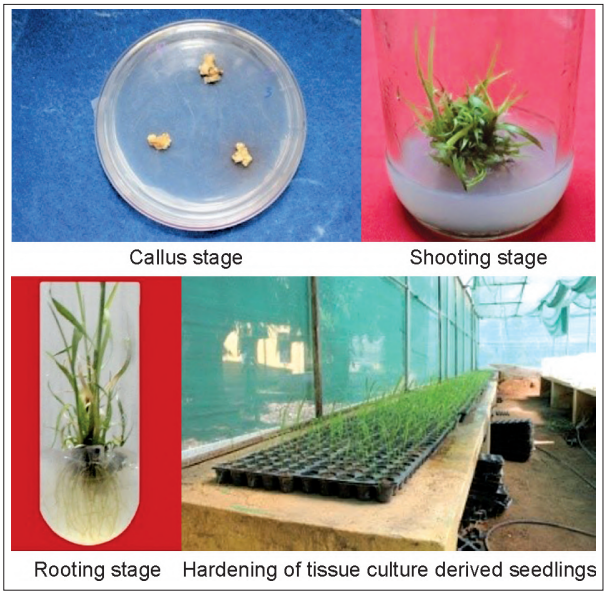
Odisha state for release as CR Dhan-317 for BPH endemic areas of Odisha.

- The entomopathogenic fungus namely, *Beauveria bassiana* and *Metarhizium anisopliae*, used for the first time in Himachal Pradesh for the management of mites on apple, were also highly efficacious. The combination of horticultural mineral oil with Hexithiazox provided encouraging results, whereas Hexithiazox alone was the least effective treatment.
- A document entitled, "Rice germplasm screening: A promise for brown planthopper resistant varieties" was prepared, which contained reaction

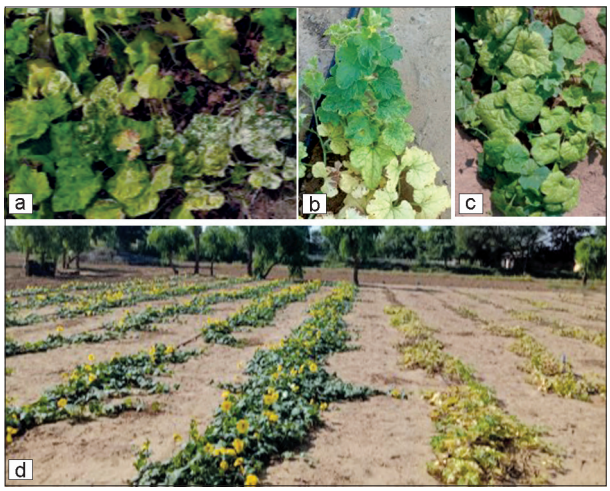
CR 2711-76 (CR Dhan 317), highly resistant to BPH, recommended for release in Odisha

of more than 6000 genotypes to BPH screened along with multiple resistance trait of BPH-resistant genotypes to YSB and gall midge.

- Standardized a reproducible protocol for production of sugarcane seedlings through micro-propagation in popular (2003V46) and pre-release clones (2016T7).

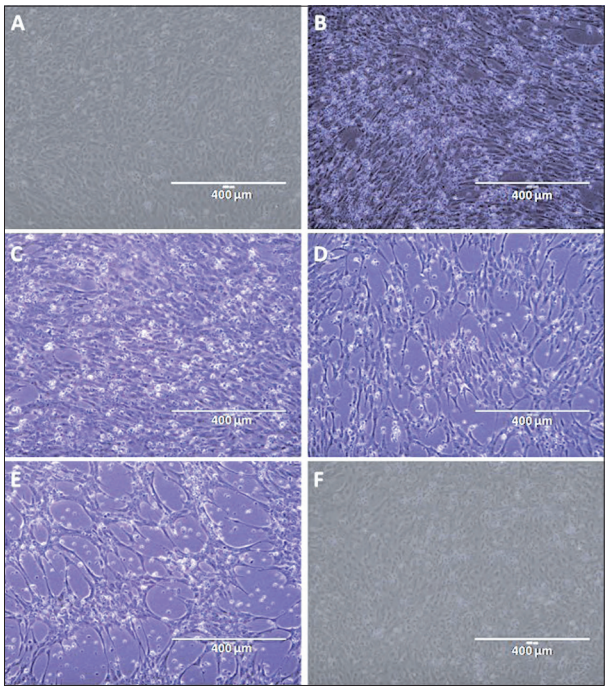


- Identified a distinct Polerovirus species, Pumpkin Yellows Virus (PuYV), infecting pumpkin, round melon, and ridge gourd hosts for the first time in the world [origin of hosts: New Delhi, Bikaner (Rajasthan), and Gorakhpur (Uttar Pradesh)].
- Sensitive and specific diagnostic assay was developed for the detection of warble fly infestation in goats, and eradication of the disease from Jammu and Kashmir. The patent for the recombinant hypodermin C based iELISA was 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).

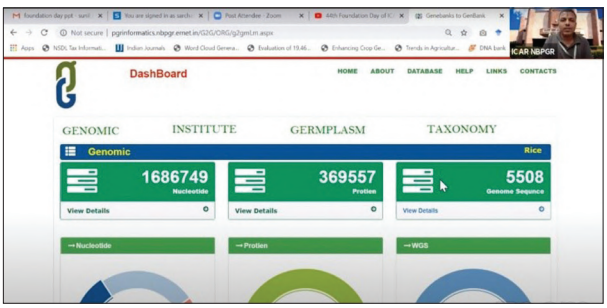


Polerovirus infection on cucurbit hosts. Blistering and chlorosis on pumpkin (a), Yellowing and chlorosis in round melon (b), Yellowing in ridge gourd (c), and Infected ridge gourd field (d).

- Identified a whitefly transmitted Cucurbit chlorotic yellows virus (CCYV), a *Crinivirus*, infecting lettuce host. This forms the first report of occurrence of CCYV in India [origin of host: New Delhi].
- Recombinant protein expression (ORF 66, 115, 131, 132, 136 and 92) in *E. coli* BL21 (DE3) pLysE cells was checked by analyzing host cells containing empty pET32a (+) vector and recombinant pET 32a (+) vector, with and without IPTG induction.
- For management of phytophagous mites in apple orchards and polyhouses of Himachal Pradesh, survey studies were conducted in different agro-climatic regions of Himachal Pradesh, viz. temperate, sub-temperate and sub-tropical. Out of 28 species of mites identified, 8 species were new to the state and few species belonging to the family Stigmaeidae were recorded for the first time in India.
- Formalin-inactivated whole CyHV-2 vaccine prepared in fantail goldfish fin (FtGF) cell line showed a significant up-regulation of the genes CD8 and IFN-Ò by the 6 h post-vaccination onwards in vaccinated goldfish, and experimental challenge in immunized goldfish showed the relative survival of 81.3% after 30 days of post-vaccination.
- A standard feeding schedule for rainbow trout farming practices was determined and developed for the first time for economical and eco-friendly trout production in the Himalayas.
- The protocols for broodstock development up-scaled, breeding, larval rearing and fingerling production of striped snakehead (*Channa striatus*), for species diversification and conservation, first-time, hatchery-produced and feed-weaned fingerling of striped murrel (*Channa striata*) were successfully reared to brood size with complete maturity in captive condition on the commercial pellet diets with 85% survival in 18 months.
- To transfer the technology of induced breeding and seed production of striped murrel to stakeholders, distributed hatchery-produced and feed-weaned 300 one-year-old yearlings and 515 fingerlings for raising broodstock.
- The application Genebank to Genbank was launched for public use (http://www.nbpgr.ernet.in/News_Details/aid/253.aspx). Application accessible at: *pgrinformatics.nbpgr.ernet.in/g2g*, which is a web-enabled application developed for accessing information on material conserved in Medium Term Storage modules of genebank system. An application combining information on all complementary conservation strategies was developed. The application is accessible at:



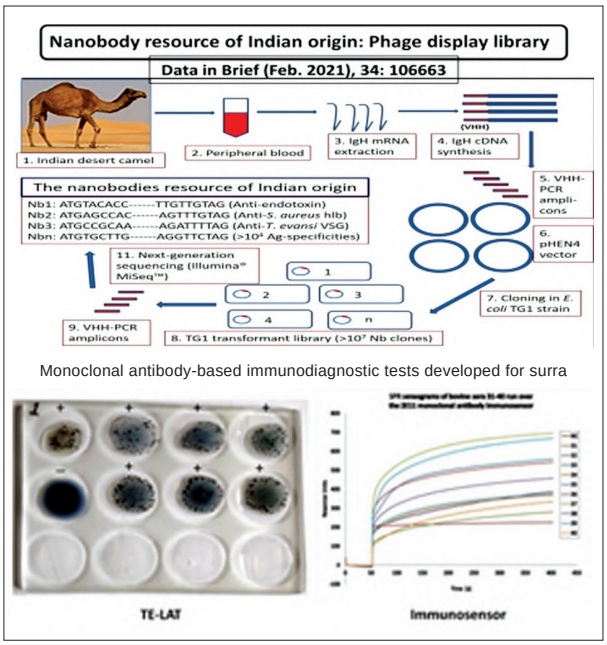
The effect of morphological changes observed in FtGF cells after inoculating with differing concentrations of formalin-inactivated CyHV-2. (A) Cell treated with 0.1% formalin-inactivated vaccine with healthy cells with no morphological changes, (B) Cells incubated with 0.3% formalin-inactivated vaccine showing rounding and vacuolation of cells, (C) Similar rounding and vacuolation of cells were also observed in the cells treated with 0.5% formalin-inactivated vaccine leading to cluster formation in FtGF cells. Elongation of the cells and detachment of cells was observed in the FtGF cell lines inoculated with 0.7%, (D) and (E) 1% formalin-inactivated CyHV-2, (F) Control cells with no incubation with vaccine showing healthy cells.



Genebank

pgrinformatics.nbpgr. ernet.in/conservation

- The first Indian immunobiological resource of the sequenced 'Nanobodies' generated: A library of Nanobodies (single-domain antibodies) of DNA sequences determined by Next-generation sequencing technology and analysed by bioinformatics tools.
- Under urbanization effects on dietary diversification and nutritional status of adolescents in rural-urban interface, the first Community Project under ICAR, UAS (B), which has obtained Ethical Clearance for conducting community research work in the field of nutrition and health.The research focusses on having gender equality by giving prime importance to both the genders (adolescent boys and girls) in the field of nutrition and in this regard conducted various nutrition training programs using developed education materials.



Monoclonal antibody-based immunodiagnostic tests developed for surra

Immunobiological products developed, submitted and registered

- Eight monoclonal antibodies, including three epitope-mapped against *Trypanosoma evansi* RoTat1.2 produced by hybridoma technique, two of which were registered at 'The Antibody Registry'— (https://www.antibodyregistry.org/); Antibody accession no.: 2890169 (2E11) and 2890170 (1C2), and Nanobody clones selected from the phage display library for surra diagnostics, and sequences submitted to NCBI genetic sequence database GenBank® — [https://www.ncbi.nlm.nih.gov/genbank], with Accession no. MW310247 and MW310248.
- A temperature controlled biomass pyrolysis reactor for production of bio-oil from different types of biomass developed and fabricated. Bio-oil production process from ground pine needles conducted with recovery of 25% bio-oil.

Direct Benefit Transfer (DBT)

The end to end digitisation of DBT onboarded schemes were initiated and completed for five schemes through NIC ServicePlus platform. The integration of the ServicePlus with Treasury Single Account (TSA) is underway for making the schemes live on ServicePlus.

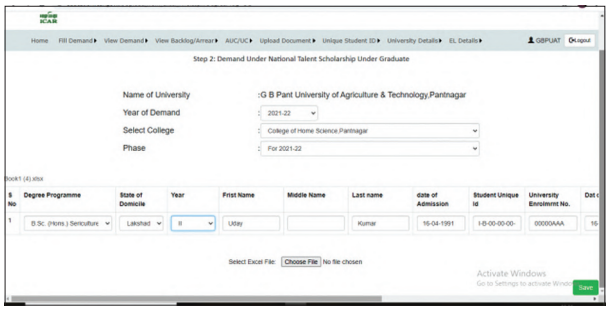
National Information System on Agricultural Education

Education portal-ICAR (https://education.icar.gov.in) has been developed as a single window platform for providing vital education information/announcements/events/schedules/e-learning resources from AUs across the country.

All the components of the scheme of Agricultural Education Division are incorporated in this portal, with functions to upload demands, AUCs, unspent amount, reports, generation of sanction letter, etc. The portal has been updated for USID, along with interface with DARE DBT portal. Other important resources have been developed and have interface with education portal, viz. CBP, E-grant, Krishi Shiksha, Accreditation, AURS, AU-GRMS, Agri-Diksha, etc.

Functionality was developed to receive Netaji Subhas - ICAR International Fellowship applications online for the year 2021–22. The submission of applications is linked with Education Portal. The portal was also strengthened with need based other functionalities. Reports were added on budget utilization and demand part for various schemes. Sanction letters were issued for grants of different schemes of Education Division.

Module was developed for Experiential Learning (EL) program. The information on year-wise number of students trained, total income generated, profit shared per student and skill imparted, entrepreneurs developed as well as related data can be entered along with photographs. MIS reports were developed for tracking status of EL. This module was made functional for submitting the necessary information regarding EL modules in the Meeting of Experiential Learning Coordinators of SAUs organized by Education Division, ICAR.



Infrastructural support for teaching and learning facilities

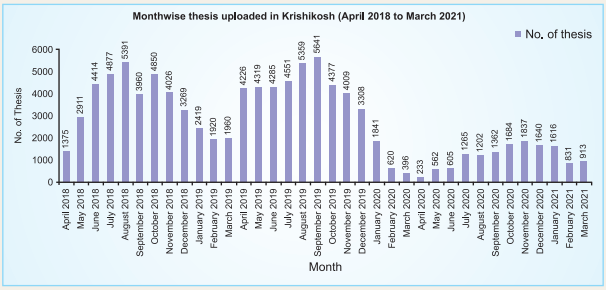
The support under the component 'Development and

Library strengthening

The library strengthening grants have an impact upon the quality of education imparted in the agricultural universities as evident by the number of students qualifying for various national and international examinations. Latest books, e-journals, etc. helped students to improve research, formulate projects, and led to improvement in publication quality and helped them compete at national and regional level competitions. The strengthening of library also helped improve quality of research by PG students, and around 1863 Ph.D. thesis were submitted as per data received from 54 AUs. This has resulted in total of 5,303 publications out of PG research, of which 2,500 are in NAAS rating 5.0–7.5 and 486 in NAAS rating of above 7.5. This year, under this component, funds were mainly provided under E-granth project.

Library strengthening

Krishikosh is a digital repository (https://krishikosh.egranth.ac.in/) which captures, preserves, archives and provides policy based access to the intellectual output of Indian National Agricultural Research and Education System (NARES). Presently, the digital repository has 40 million digitized pages in two lakh ten thousand digital items (volumes) like old books, old Journals, reports, proceedings, reprint, research highlights, training manuals, historical records, which includes more than one lakh fifty thousand theses digitized from various NARES Institutes/ SAUs. Through E-granth, the Krishikosh platform can be accessed on 24×7 basis and provide semantic search and retrieval facilities to share library resources.Till date 167,972 theses have been uploaded in the Krishikosh repository.



Status of theses uploaded on Krishikosh

Strengthening' continued during the year. The on-going new civil works, viz. 5 hostels, auditorium were supported. However, support was mainly provided for renovation and refurbishing of old existing structures, with emphasis on improving amenities for students, viz. modernization of hostels, upgradation of laboratories, classrooms. Teaching facilities were further enhanced with additional support for 22 virtual/smart classrooms as provision for these virtual classrooms with most up to date audio visual aids, was of utmost importance for non-stop teaching in view of COVID-19 pandemic. This pandemic and subsequent lockdowns, changed education dramatically, with the distinctive rise of e-learning, whereby teaching is undertaken remotely and on digital platforms and enabled effective delivery of course curriculum, ensuring enriched learning experience.

Funding support also continued for AUs for conducting UG and PG practicals 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, to ensure the quality of higher agricultural education.

Communication labs helped improve the language skills of the students as per requirement. 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. Practical manuals were developed in various subjects. Overall personality development and leadership programmes with the support from the Council helped the students become better persons and to grow as individuals.

The hostel facilities for the students were improved with support from the Council. The improved amenities and infrastructure attracted talented students. The support also helped improve amenities in the hostels and other services in the campus, including facilities for disabled. 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 Scheduled Tribe Component

The support under STC was provided to 29 Agricultural Universities during 2020–21 for agricultural and allied activities in the tribal areas. The major agricultural and allied activities conducted were,

PG laboratories upgraded with modern equipments

Modernized and upgraded UG and PG laboratories

viz. 69 training/ skill development/ capacity building programmes, 2976 demonstrations (FLDs/ OFTs), 42 Awareness camp/ Exhibitions/ Exposure visits and distribution of inputs (Quality maize seeds, piglets, goats, seedlings for various fruits, vegetable seeds, poultry birds for backyard poultry, egg incubators) to approximately, 16,665 tribal beneficiaries to improve their livelihood.

Support under Scheduled Caste Sub Plan (SCSP)

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 total grant of ₹4,393.21 lakh was released to 37 agricultural universities located in 15 states during 2020–21. 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 to the scheduled caste beneficiaries at college/university level. Book banks were created for the SC students enrolled in the AUs. More than 8,000 books were added in 15 Agricultural Universities, which were then distributed to the SC students.

Support under North Eastern Hill Region (NEH)

During the year 2020–21, 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 ₹1,706 lakh. Among new civil works one hostel and two examination halls and 25 new smart classrooms were developed in various colleges. Practical classes were also conducted in e-learning mode through videos, and laboratories were modernized/upgraded and equipped with state-of-the-art facilities. 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, library software like Koha, Ezproxy, ICT tools and accessories and other logistics has helped in better learning and advanced research. Execution of a major agro-ecotourism project under green initiative is underway. Augmented the process of entrepreneurship and skill development of the students through introduction of new/ existing Experiential Learning Units and support for practicals in form of contingency and research expenses enabled PG research and smooth conduct of practical classes in both UG and PG degree programmes.

Active coordination with AUs on various aspects

To discuss the roadmap and process of implementation of New Education Policy (NEP-2020) meeting of Vice Chancellors of AUs was held on 26 August 2020. To actively review, refine and strengthen various programmes implemented by the Education Division of ICAR the virtual annual meetings of Vice Chancellors' was successfully held on 4–5th December 2020 and on 28 September 2021.This provided an opportunity to the Vice-Chancellors of AUs to interact with each other and develop strategy for effective functioning to maintain quality standards in higher agricultural education in the country as well as for effective implementation of the newer initiatives. The virtual Nodal Officers meeting was conducted on 11 January 2021. All the nodal officers were apprised of the recent steps and new initiatives taken by ICAR.The library is an important source of knowledge and librarian meet was held on 16 September 2021; meeting of Experiential Learning coordinators was organized on 6 and 9 August 2021, to streamline the important component of the scheme. For smooth conduct of scheme activities and utilization of funds efficiently for the purpose they are released, Comptrollers meet was organized on 22 September 2021. The Education Division

identified various IT solutions and shared with the Universities 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 Amrut Mahotsav. To commemorate the 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 Amrut Mahotsava" lecture series, 35 lectures have been completed during this period.

ICAR-National Agricultural Higher Education Project (NAHEP)

NAHEP is designed to strengthen the national agricultural education system in India with overall objective to provide more relevant and high-quality education to agricultural university students. This programme is striving to promote efficiency and competitiveness through changes in working mechanism of agricultural universities, raising the teaching and research standards through improved research and teaching infrastructure and enhanced faculty competency and commitments, and making agricultural education more attractive to talented students. There are four key components under NAHEP, namely, Institutional Development Plan (IDP), Centres for Advanced Agricultural Sciences and Technology (CAAST), ICAR to support excellence in agricultural universities (AUs), and ICAR Innovation Grants to AUs. It is envisaged that improved AU performance through quality enhancement, better employment and entrepreneurship opportunities created for agriculture graduates, non-accredited AUs attaining ICAR accreditation, and institutional reforms implemented in education division of ICAR and AUs under these components together shall contribute to the achievement of the overall program objective.

NAHEP is implemented by ICAR (GoI) and World Bank with the total project cost of USD 165 Million (INR 1100 Cr approximately at 1USD=INR 64.47 as on 1 June 2017), having 50:50 cost sharing between GoI and World Bank.

The beneficiaries of NAHEP include 74 institutions that form the ICAR-AU System, which encompasses 64 State-level AUs, 4 Deemed Universities, 4 Central Universities with Agricultural Faculty and 3 Central Agricultural Universities. Direct project beneficiaries of the project are those students and faculties, who directly derive benefits under IDPs, CAASTs, IGs and activities under Component 2.

Till now, 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 3 ICAR institutes, i.e. ICAR-Indian Agricultural Statistics Research Institute (IASRI), ICAR-National Institute of Agricultural Economics and Policy Research (NIAP) and ICAR-National Academy of Agricultural Research Management (NAARM) have been implementing Component 2 of NAHEP.

	NAHEP cost by Component	Budget	
		USD Million	INR Crore
1.	Support to Agricultural Universities		
a.	Institutional Development Plans (IDPs)	69.4	447
b.	Centres for Advanced Agricultural Science and Technology (CAASTs)	46.2	297
c.	ICAR Innovation Grants to AUs	30.8	198
2.	Investment in ICAR in Agricultural Higher education	10.4	67
3.	Project Management and Learning	8.0	51
4.	Front-end Fee	0.2	13
	Total	165.0	1,063

IDP financed activities majorly focus on teaching and research infrastructure development, faculty development and training, networking and industry collaboration, vocational training, students job placement, and own revenue generation. Till date, students and faculties together have completed the international level trainings in reputed foreign universities on 101 different subject areas hosted by 45 different international institutions. Also, more than 3000 national level workshops/ seminars were conducted for UG level students under IDP. Among these trainings and workshops, high impetus was laid on enhancing employability and building entrepreneurship capabilities of agricultural students, so that the ripple effect of program in society could be enhanced. Moreover, industry visits and Skill development programs have also been organized majorly to cater the current market needs and enable the students to emerge as "Job Creators" rather than "Job Seekers".

Under CAAST Component, 16 sub-projects were awarded to AUs, spread across 11 states of the country. The major activities undertaken by AUs under 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 June 2021, students have completed international trainings in more than 43 emerging areas from 40 international HEIs spread across 15 different countries whereas more than 2,500 national level trainings/ seminars have been conducted to develop scientific entrepreneurship of students and enhance research effectiveness.

IG projects were awarded to select participating AUs to attain accreditation. Till date, 24 sub-projects have been awarded under this component. Key IG activities include

Component of NAHEP	Key objectives and focus	Awarded institutions
1. Support to AUs		
a. Institutional Development plans (IDP)	Quality enhancement, thrust on business entrepreneurship and employability, internal revenue generation; focus on UG students	22
b. Centres for Advanced Agricultural Science and Technology (CAAST)	Scientific entrepreneurship, employability and research effectiveness; focus on PG students	16
c. Innovation Grants (IG)	Attain accreditation with revised norms and standards of ICAR	24
2. Investments in ICAR	Institutional reforms	3
Total Beneficiary institutes covered under NAHEP		62

national level trainings for faculty up-gradation, master and Ph.D. sandwich programs, alumni linkages, industry seminars and professional workshops, e-enabled learning activities, etc. It is worth mentioning here that, in last two years 7 AUs under the IG have attained ICAR accreditation due to NAHEP support and interventions. Due to ongoing Covid pandemic, PRT reviews of few additional AUs are pending with ICAR-Agricultural Education Division and shall be completed at the earliest in current FY.

Component 2 aims to support ICAR to carry out institutional reforms within ICAR and enhance effectiveness in coordinating, guiding and managing agricultural higher education in the country. Till date, activities undertaken entail strengthening of key digital infrastructures of ICAR-AU system such as ICAR-DC, establishment of KRISHI Megh—a disaster recovery centre (cloud infrastructure), launch of AGRI-DIKSHA—an Agri Web Education Channel, implementation of Academic Management System in 53 AUs, development of e-learning portal, establishment of 5 CDC and 1 FDC, organization of external advisory panel committee meeting.

The major activities and achievements under Monitoring and Learning component include regular monitoring of sub- projects through Project Monitoring and Tracking System (PMTS), capacity building activities, documentation of learnings and achievements, etc. In addition to these activities, central M&E team has taken other important initiatives as well such as assessment of the measurable intermediate outcomes through Mid-line survey, Development and implementation of AU Implementation Performance Scoreboard (AUIPS), Satisfaction mapping of direct project beneficiaries, organizing M&E Clinics, etc. In order to establish a fair and transparent system, while effectively addressing the grievances of project stakeholders, a 3 tier Grievance Redressal Mechanism has also been established at PIU NAHEP and has been made fully operational.

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 Ag. Tech. Hackathon, Promoting Resilient Agricultural Education System (RAES), Strategic study

Launch of AGRI-DIKSHA

Project Monitoring and Tracking System

to assess the requirement of human resources in agriculture and allied fields for next 20 years, etc. These initiatives under PIU have commenced during the FY 2020–21 and would play a pivotal role in improving the overall quality and relevance in agri higher education in the country. The infrastructure developed, teaching, learning and skill upgradation initiatives under NAHEP are very much aligned with the National Education Policy (NEP) 2020 formulated by Government of India.

Digital interventions to improve learning outcomes

During the year, digital interventions undertaken at partner AUs under IDPs have played a pivotal role in improving the learning outcomes of students. Over the

MoUs

The NAARM, Hyderabad signed an MoU with Vaikunth Mehta National Institute of Cooperative Management (VAMNICOM), Pune, a Grant-in-aid Institution under Department of Agriculture, Cooperation and Farmers Welfare on 2 September 2021 at the Academy, for Joint Product Development with eight empaneled firms.

Learning and Assessment Centre (LAC)

Promoting Online and Digital Education

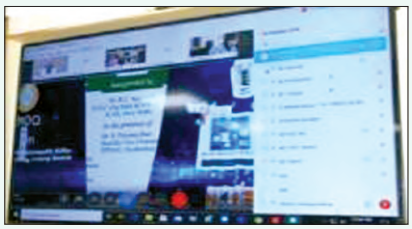
The Academy has established the Centre of Lifelong Learning in Agricultural Education which is involved in handholding, production and organizing online learning programmes. The Center organized MOOCs in Education Management and developed more than 150 Video-lectures.Since November 2020, Academy offered one MOOC programme and benefitted about 2,356 learners across the country, impacting the quality of education especially during the current pandemic.

last year, IDP AUs have taken various digital initiatives such as development of Learning and Assessment Centre (LAC), establishment of e-content studio, conducting online examinations of students, development of AI Labs, trainings on digital automations, etc.

ICAR-National Academy of Agricultural Research Management (NAARM)

Research and Policy Advocacy: The Academy published policy briefs and documents on – Mainstreaming Biodiversity in Agri-Development Schemes, Ease of Doing Research, Policy Issues and Stakeholder Requirements in Indian Meat Sector and Circular Carbon Economy in India. During the reporting period, 63 research papers, 22 book chapters, 8 popular articles, 4 Policy papers and 13 books were published besides 4 copyrights and 5 project reports. 24th and 25th Institute Research Council meetings were held during this period, and currently 23 in-house projects and 8 extra mural projects are on-going in the academy.

Training and capacity building: A total of 37 probationers successfully completed the 111th FOCARS during 5 October 2020 to 2 January 2021. The Academy also organized 69 capacity building programs benefitting

Digital Intervention	Brief	
Learning and Assessment Centre (LAC) by TANUVAS, Chennai	• Partner AU has established LAC facilities wherein actual size animal simulations have been enabled with Holstein dystocia simulator, Haptic Vet Cow simulator, Canine Surgical simulator, etc. • These simulation models are being used to provide the real near experience to the students without harming the actual animals. • Practical sessions were organised for students in LAC to enhance the learning outcomes of the students and to provide the clinical experience of various categories of animals/ species.	 
Solar operated power sprayer developed by VNMKV, Parbhani Virtual Macmillan English Campus established by SKRAU, Bikaner	• The IoT based camera is mounted for monitoring and addressing both voice and video signals that are continuously being transmitted on the 4G communication network for remote visualization. • Necessary energy requirement is being fulfilled by the battery mounted on the robot. The battery can be charged through the solar panel mounted on the robot or electrical supply. • To improve the English language proficiency, partner AU has established a suitable facility with 3-year subscription of virtual courses by Macmillan English. • A total of 200 students have been availing the benefits through these virtual classes.	 

Dr Trilochan Mohapatra, Secretary DARE and DG ICAR with 111th FOCARS Probationers and Faculty at NAARM

Promoting Start-Ups and Agripreneurship

During the reporting period eight agricultural Start-Ups were incubated. Food and agriculture accelerator programme AGRI UDAAN 4.0, organized by a-IDEA, the Technology Business Incubator of ICAR-NAARM, was launched on 17 May 2021. The a-IDEA has organized two-day national entrepreneurship ideation competition "Aggnite" to stimulate entrepreneurship among students where 211 teams from 150 top Institutes in the country, viz. Agricultural Universities, IITs, IIMs and other renowned institutions took part in the event during 24–25 September, 2021. The a-IDEA invited innovators working on innovative Idea/POC/ Prototype stage to apply for "NIDHI PRAYAS" grant up to ₹10 lakh in the field of agriculture and allied sectors and also sector as a BIRAC BIG Partner called application for the 18th Call of BIRAC's Biotechnology Ignition Grant (BIG) scheme in the Agri and Agri-Biotech. Agri-BioNEST, an Agri-Biotech-focussed Bio-Incubator of a-IDEA, NAARM and Agri-Biotech Foundation organized the Global Bio-India 2021 Roadshow virtually on 25 February 2021.

4,437 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).

Agri-business and technology management: The 11th batch of PGDM-ABM successfully completed its 2-year residential programme at the Academy. All the 48 students of PGDM-ABM (2019–21) have been placed successfully in 20 reputed agribusiness companies. The package offered ranged between ₹ 6.5 lakh and 12 lakh per annum (lpa), with an average CTC of ₹ 8.5 lpa. During this period, a total of 61 students were admitted for 13th batch of PGDM-ABM, and 29 students are pursuing Diploma in Technology Management in Agriculture (DTMA). The Academy also initiated a new distance education programme on Diploma in Educational Technology Management (DETM) in collaboration with University of Hyderabad (UoH) in 2019, in which 32 students are currently enrolled.

❑

12. Social Science

Agriculture economics and policy

Income scenario of agricultural households: Income scenario of agricultural households in India along with variations in various income components were examined across different rounds of the Situation Assessment Survey of Agricultural Households (SAS-AH). Agricultural households usually derived income from farm and non-farm sources. For the latest 77th Survey, an additional category of income from the leased out land has been added to the income of agricultural households. The income comparisons have been made for SAS 2002–03, 2012–13 and 2018–19. The incomes have been converted to 2018–19 base with two suitable deflators: Consumer Price Index for Agriculture Labour (CPIAL) and GDP deflator.

Though the overall income for agricultural households has increased during the last two surveys, their income from the production of crops or allied activities has declined in real terms. Much of the increase in income seems to have come from wages and farming of animals. During 2018–19, wages comprised the maximum share in the income of an agricultural household (contributing to around 40% of the total average monthly income) followed by the income from crops. During 2002–03 to 2012–13, the real income (with GDP deflator) grew by 2.47% per year. Income growth has narrowed down to 1.5% per year during 2012–13 to 2018–19.

Measuring agricultural sustainability of Indian states: Agriculture is the common thread holding 17 Sustainable Development Goals (SDGs) together. Threat to agricultural sustainability hence will weaken this thread and jeopardise the overall achievement of SDGs. Despite the increase in number of studies, significant gaps remain in assessment of agricultural sustainability in general and strong sustainability, in particular. Here we present a strong agricultural sustainability report of 24 Indian states, employing 51 indicators across four dimensions: soil, water, environmental and socio-economic. We found moderate level of agricultural sustainability in India with the Composite Index of Agricultural Sustainability (CIAS 0.41–0.57). The inter-state variations in CIAS are quite pronounced. The arid western state of Rajasthan was the least sustainable (CIAS 0.41) while north-eastern state of Mizoram was the most agriculturally sustainable followed by Manipur, Andhra Pradesh, Madhya Pradesh and Kerala**.** The CIAS scores were below the half mark for more than half of the states. The bottom rank of the state of Rajasthan was followed by states in Indo-Gangetic Plain (IGP) like Uttar Pradesh, Punjab, Bihar and Haryana. Besides IGP, rice dominated states of Jharkhand and Assam also performed poor in terms of agricultural sustainability. Much of India's food grains supply, particularly staple foods like wheat and rice comes from these states and sustainability threats in this region has serious implications on country's overall sustainability performance.

Though the performance was consistently moderate across all the dimensions, water and socio-economic dimensions were the major concerns, in general. Yet the various states have widely varying pattern of agricultural sustainability with unique priorities for improvement. The notable among these are incomplete, deficiency of soil organic carbon and secondary and

Average monthly income of agriculture households

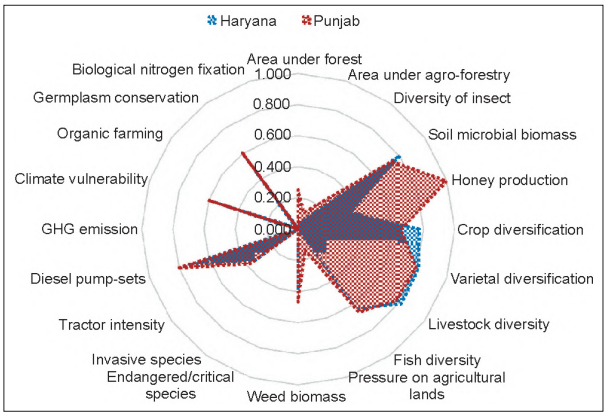
Income	Year	Wages	Crop production	Farming of animals	Leasing out of land	Non-farm business	Total income
Nominal income	2002–03	819	969	91		236	2,115
		(39)	(46)	(4)		(11)	(100)
	2012–13	2,071	3,081	763		512	6,426
		(32)	(48)	(12)		(8)	(100)
	2018–19	4,063	3,798	1,582	134	641	10,218
		(40)	(37)	(15)	(1)	(6)	(100)
Real income with CPIAL, 2018–19 prices	2002-03	2,340	2,769	260		674	6,043
		(39)	(46)	(4)		(11)	(100)
	2012–13	2,749	4,090	1,013		680	8,532
		(32)	(48)	(12)		(8)	(100)
	2018–19	4,063	3,798	1,582	134	641	10,218
		(40)	(37)	(4)	(1)	(6)	(100)
Real income with GDP deflator, 2018–19 prices	2002–03	2,836	3,355	315		817	7,323
		(39)	(46)	(4)		(11)	(100)
	2012–13	3,011	4,480	1,109		745	9,344
		(32)	(48)	(12)		(8)	(100)
	2018–19	4,063	3,798	1,582	134	641	10,218
		(40)	(37)	(15)	(1)	(6)	(100)

Numbers in parentheses indicate the percentage share.

micro nutrients, high chemical pesticides use intensity, fast depleting groundwater, excess use of fertilizer, loss of crop diversity, high gaseous emission, etc. High input subsidies were associated with large area under unfavourable soil *p*H, deficiency of soil organic carbon, groundwater overexploitation, and less area under natural and organic farming. A trade-off between socio-economic and environmental factors was observed.

The Eastern states of Bihar, Jharkhand, Assam and Chhattisgarh were laggard in agricultural sustainability, mainly because of poor economic efficiency. Besides, soil health dimension was equally poor in these states, mainly due to problematic soils (acidic soils). In the eastern and north-eastern region of the country, improving cropping systems by strengthening infrastructure, particularly irrigation potential, improving productivity, small farm mechanization, developing stress tolerant varieties are the top priority identified for sustainable intensification. Given the strong linkages between the core agriculture sector and other areas of the rural economy, the policy focus should be on comprehensive rural development, which could also enable a much stronger revival of the agriculture sector in the region. Crop and enterprise diversification were found to be the major resiliency instruments in arid and semi-arid regions like Rajasthan, Gujarat, Karnataka, Maharashtra and Tamil Nadu. The scores of indicators like productivity of livestock, crop diversification, etc were quite satisfactory in most of these states. Agricultural support services, particularly livestock support services, reviving traditional system of common property resources (Pastures and grazing lands, community water storage structure) are extremely important in the arid and semi-arid region to support diversified production system and livelihoods of farmers. Promotion of agroforestry based production system will further strengthen crop-livestock linkages in these states.

Modelling agroecosystem diversity: Moving beyond taxonomic diversity: Agroecosystem diversity have potential to address major challenges of ensuring food security, climate change, increasing population and sustaining agriculture. A system based and holistic approach is required towards achieving biodiversity targets defined by international treaties and conventions at national as well as international levels, especially of Conventions on Biodiversity and Sustainable Development Goals. Going beyond the taxonomic level of diversity, we propose Agroecosystem Diversity Index (ADI) to assess the diversity of agroecosystems blending 20 indicators grouped under four major themes: landscape and ecosystem diversity, genetic and species diversity, agrobiodiversity threats, and societal response. The application of ADI in Trans-Gangetic Plains of India reveled that agroecosystem in the region has become highly specialized, making agriculture more sensitive to numerous biotic and abiotic shocks. Though there was not much inter-district variability in the ADI, in the districts falling in Shivalik hills. Districts with offshoots of Aravali slope are dominated by dry mixed deciduous forests. Major concerning dimensions were threats to agrobiodiversity and inadequate response to reverse the agrobiodiversity losses. The average normalized values of indicators of the state are depicted in figure which shows that the performance of region was consistently low across indicators except a very few. For most of the indicators, the actual values were not up to the mark in respect to the identified diversity benchmarks. Though, efforts are being made for *ex situ* conservation of germplasm, conserving plant genetic resources under its native environment is much more practical. The methodology developed is helpful in computing index comparable the agroecosystem diversity spatially and temporally.



State average normalized value of agrobiodiversity indicators

Price transmission in major pulses value chain: The direction and extent of price transmission along the value chain of major pulses in Delhi were analyzed using monthly data collected from DES and DoCA for the period January 2009 to December 2019 for grain wholesale, dal wholesale, and dal retail. The gram/tur value chains analysed are Chain-I: gram/tur wholesale-dal wholesale; Chain-II: dal wholesale-dal retail; and Chain-III: gram/tur wholesale-dal retail.

The Johansen cointegration analysis for gram/tur value chains indicated one cointegrating vector between the dal wholesale and gram/tur wholesale (Chain-I), and dal retail and gram/arhar wholesale (Chain-III) meaning that these price pairs are cointegrated and move together in the long-run. However, the results indicated no cointegrating relationship in Chain-II for both the pulses.The causality tests (wald) are performed for gram value chains (Chain-I: grain wholesale- dal wholesale; Chain-II: dal wholesale- dal retail; Chain-III: grain wholesale- dal retail) based on the estimated VECM models in the Johansen framework indicated that the upstream prices dominate the downstream prices and thus, play a price discovery role in the vertical markets analysed. In the case of tur, the wald test for causality results (long-run, short-run and strong exogeneity) indicated that the wholesale price of dal granger causes Tur wholesale price in Chain-I. However,

Wald test for causality in Gram and Tur value chain

Vertical chain	Causation	Hypothesis	Gram		Tur	
			χ^2-test stat	Causality	χ^2-test stat	Causality
Chain-I: GrWP-dWP	Long-term causality	$\alpha_1=0$ vs $\alpha_1\neq0$ $\alpha_2=0$ vs $\alpha_2\neq0$	10.345*** (0.0013) 1.482 (0.223)	Unidirectional (DalWP–GrWP)	13.346*** (0.0003) 1.214 (0.2704)	Unidirectional (DalWP-TurWP)
	Short-run causality	$\Sigma\beta_i=0$ vs $\Sigma\beta_i\neq0$ $\Sigma\beta_j=0$ vs $\Sigma\beta_j\neq0$	18.173*** (0.001) 41.264*** (0.000)	Bidirectional	12.306*** (0.0021) 0.761 (0.684)	Unidirectional (DalWP-TurWP)
	Strong exogeneity	$\Sigma\beta_i=0$, $\alpha_1=0$ vs $\Sigma\beta_i\neq0$, $\alpha_1\neq0$ $\Sigma\beta_j=0$, $\alpha_2=0$ vs $\Sigma\beta_j\neq0$, $\alpha_2\neq0$	21.910*** (0.0005) 49549*** (0.000)	Bidirectional	40.462*** (0.000) 2.976 (0.424)	Unidirectional (DalWP-TurWP)
Chain-III: GrWP-dRP	Long-term causality	$\alpha_1=0$ vs $\alpha_1\neq0$ $\alpha_2=0$ vs $\alpha_2\neq0$	8.545*** (0.0035) 1.051 (0.305)	Unidirectional (DalRP-GrWP)	5.630** (0.0177) 4.101** (0.043)	Bidirectional
	Short-run causality	$\Sigma\beta_i=0$ vs $\Sigma\beta_i\neq0$ $\Sigma\beta_j=0$ vs $\Sigma\beta_j\neq0$	17.458*** (0.0016) 40.510*** (0.000)	Bidirectional	1.147 (0.284) 7.662*** (0.006)	Unidirectional (TurWP-DalRP)
	Strong exogeneity	$\Sigma\beta_i=0$, $\alpha_1=0$ vs $\Sigma\beta_i\neq0$, $\alpha_1\neq0$ $\Sigma\beta_j=0$, $\alpha_2=0$ vs $\Sigma\beta_j\neq0$, $\alpha_2\neq0$	19.522*** (0.0015) 52.386*** (0.000)	Bidirectional	8.942** (0.0114) 13.950*** (0.0009)	Bidirectional

in Chain-III, long-run and strong exogeneity tests supported the bidirectional causality between the retail price of dal and wholesale price of Tur.

Threshold cointegration (TAR, MTAR and their consistent counterpart) and test of long-run asymmetry in the speed of adjustment were estimated for both pulses for chain-I and chain-III. The consistent MTAR model has the best threshold value with the lowest sum of squared errors estimated for both the supply chains of gram (I and III). The point estimates (MTAR model) for the price adjustment in gram value chain I is –0.456 for negative shocks and –0.189 for positive shocks, implying that the negative deviations from the long-run equilibrium resulting from an increase in dal wholesale price or decrease in gram wholesale price ($\Delta\xi t–1>= 0.01$) were eliminated faster at 45.6% per month (takes 6 months to converge to long-run equilibrium). However, the positive shocks were eliminated at 19% per month (takes about 2 months). In the case of gram value chain III, the positive shocks adjusted faster (four months) than the negative shocks (six months) in the long-run equilibrium. In the case of tur chain-I, negative deviations takes about 3 months, whereas positive deviations takes 6 months to adjust to the long-term equilibrium. In the case of Chain-III, positive deviations in prices adjust faster (in about two months) than the negative deviations (in about 6 months).

Vertical chain	Shock	Price adjustment	
		Gram	Tur
Chain-I: GrWP-dWP	Negative	–0.456** (2 months)	–0.324* (3 months)
	Positive	–0.189** (5 months)	–0.165* (6 months)
Chain-III: GrWP-dRP	Negative	–0.169*** (6 months)	–0.171* (6 months)
	Positive	–0.244*** (4 months)	–0.421* (2 months)

Long-run trends in estimated agricultural workforce and labour use in crop cultivation: The study provides empirical evidences on temporal changes in agricultural labour supply and assesses its effects on farm economy. The sub-period 1993–94 to 2004–05 witnessed an increase in agricultural workforce (usual status) by 25 million at annual growth rate of about one per cent. The size of agricultural labour did not increase and incremental agricultural workforce during this period was only due to increase in the cultivators. The subsequent period till 2011–12 witnessed an unprecedented decline in the absolute number of agricultural workers by 37 million at annual growth rate of 2.09%. The decline in agricultural workforce was due to withdrawal of both cultivators and labours, particularly female workers. The annual

Changes in agricultural workforce (usual status) in India during 1993–94 to 2017–18

Period	Cultivators			Agricultural labours			Agricultural workers		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
				Absolute numbers (million)					
1993–1994	90	56	146	58	40	97	148	96	244
2004–2005	101	72	172	57	40	96	157	112	269
2011–2012	99	52	151	51	29	80	150	82	232
2017–2018	109	39	148	33	21	54	142	60	202
				Compound growth rate (%)					
1994–2005	1.10	2.49	1.64	–0.17	0.00	–0.12	0.62	1.52	0.97
2005–2012	–0.29	–4.44	–1.88	–1.43	–4.38	–2.56	–0.68	–4.35	–2.09
2012–2018	1.75	–4.92	–0.38	–7.21	–5.02	–6.43	–0.90	–5.04	–2.29

Data source: Estimates based on NSSO estimates on activity-wise distribution of workers and census population.

rate of withdrawal of female workers was more than 4% in both cultivator and labour categories.

During the recent period 2011–12 to 2017–18, withdrawal from agriculture accelerated and another 30 million agricultural workers left agriculture. The withdrawal from agriculture sector during the recent years was primarily led by agricultural labours, while the withdrawal by cultivators decelerated. The growth rate in the decline in the female agricultural workers accelerated to 5.04% during recent period as compared to 4.35% during previous period. Interestingly, male agricultural labours declined at historically highest rate of 7.21% per annum during the latest period. Thus, successive NSSO surveys during the last 24 years have revealed consistent declining trend in agricultural labours in the country. On the other hand, declining trend in cultivators was slowing down over time. In fact, the number of male cultivators has increased between 2011–12 and 2017–18. This could be either due to limited capacity of non-farm sectors to absorb incoming workforce or effect of ongoing agricultural reforms raising their expectations about remunerative returns.

Effect of COVID-19 pandemic led change in labour supply on farm economy: After the first COVID-19 confirmed case reported on January 30, 2020 in Kerala, Indian Government took proactive step and announced nationwide lockdown on March 24, 2020 for 21 days. Owing to the rising number of cases, lockdown was further extended till May 3, 2020. As period of lockdown coincided with *rabi* harvest and *kharif* sowing seasons, agricultural activities (along with selected other essential services) were permitted with social distancing provisions. The labour-deficit states like Punjab, where farmers primarily depend on outside contractual labour for wheat harvesting and paddy transplanting, faced labour shortage to carry out these operations due to inter-state movement restrictions. The farm-level observations revealed that labour scarcity resulted in 24.4 and 46.6% increase in wages for wheat harvesting and paddy transplanting in 2020 over previous year, respectively. The effect of such wage rise on cost was ascertained using estimated price elasticity of labour and share of these operations in cost A_1+FL.

Due to the wage rise, estimated labour cost for harvesting of wheat and transplanting of paddy increased by 15.62 and 40.54%, respectively in Punjab. Multiplication of change in labour cost with its share in Cost A_1+FL provides likely effect of COVID-19 led change in labour supply on cost of cultivation. The results show 1.1 and 4.6% change in Cost A_1+FL of wheat and paddy, respectively. In absolute terms, it was ₹ 287/ha for wheat and ₹ 1,668/ha for paddy at 2016–17 prices.

In case of Bihar, it was expected that reverse migration would positively contribute to farm economy by pushing labour wages downwards due to increase in labour supply. However, farm-level observations revealed no change in labour wages as reverse migrating labour did not work at farm and preferred to work in public work programmes like Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). Also, most of the labours started coming back to urban centres as soon as lockdown was relaxed (The Economic Times, 2020). Thus, disequilibrium in labour market

Effect of COVID-19 on farm economy of Punjab and Bihar

State	Crop	Price elasticity of labour demand	Change in wages in 2020 (April–June) over 2019 (April–June) (%)	Change in labour cost (%)	Share of transplanting/ harvesting labour cost in cost A_1+ FL (%)	Change in cost A_1 + FL due to change in wages (%)
Punjab	Paddy	–0.13	46.6	40.54	11.4	4.6
	Wheat	–0.36	24.4	15.62	6.8	1.1
Bihar	Paddy	–0.18	Nil		13.9	–
	Wheat	–0.25	Nil		14.5	–

created due to reverse migration did not show any effect on cost of cultivation in Bihar.

Income induced effects on food consumption pattern of Indian households : The study has modelled consumer behaviour to simulate likely effect of income shocks on consumption pattern in the context of COVID-19. The estimated elasticities varied across different commodities, implying a differential response of change in income on consumption of different commodities. Among the food groups, cereals exhibited positive but lowest expenditure elasticity value of 0.37. Thus, with the change in income, consumption of cereals changed but only marginally. Edible oils, pulses and vegetables are relatively more elastic as compared to cereals, but in case of change in income, consumption of these commodities will change less than proportionately. For milk and non-vegetarian products, elasticities values are closer to one. Fruits and other foods exhibited elastic expenditure elasticities and change in income of the households will change consumption of these commodities more than proportionately. Overall, average weighted (expenditure share) elasticity of food is 0.80 (inelastic), implying food a necessary item for the consumers. The expenditure elasticity of non-food expenses has been estimated as 1.23. Thus, with the change in income, households will change expenditure on non-food items more than proportionately. These results indicate that with the impact of change in income on consumption will vary across different commodities depending on the elasticity values.

Trade assessment in agriculture: Trade liberalization helps accelerate economic growth in medium run by increasing the allocative efficiency and investment. Indian agricultural export has undergone significant changes during recent times. An attempt has been made to determine the causal relationships between India's growth and India's agricultural trade. We observed bidirectional causality between exports of tea, coffee, spices and fish with GDP and agricultural GDP both. The unidirectional causality exists between cotton exports and GDP, where cotton exports Granger cause GDP. Except cereals, all selected export categories Granger cause agricultural GDP. This designates that the growth in agricultural exports in general along with exports of specific commodities have led to the overall and agricultural growth of Indian economy.

Analyses of export performance for various commodity groups during 2011–14 and 2015–18 categorized various exported commodities into highly competitive, competitive, weakly competitive and uncompetitive commodities. During 2011–18, rice, frozen bovine meat, cotton yarn, raw cotton, ginger, pepper and seed spices remained highly competitive commodities. Crustaceans emerged as highly competitive during 2015–18. The results indicate no change in export performance of the cereals during the period and they remained competitive. Although, within the commodity group the scenario is interesting, as rice (HS 1006) is the only commodity which is highly competitive for India; while maize (HS 1005) and wheat and meslin (HS 1001) are uncompetitive. Meat is dominated by the exports of frozen bovine meat, India enjoys competitiveness in its exports. The performance of the other two products, edible offal (HS 0206) and sheep and goat meat (HS 0204) improved in 2015–18, however, they still remained uncompetitive. The export performance of the fish and crustaceans, molluscs and other aquatic invertebrates (HS 03) remained weakly competitive throughout. India has emerged in the competiveness of the crustaceans (HS 0306), as the status changed from competitive during 2011–14 to highly competitive during 2015–18.

Indian exports were USD 4,640 million in TE 2019 and the country is the largest crustacean exporter in the world followed by Ecuador and Canada with USA emerging as single major export destination for India. The revealed comparative advantage of India, Ecuador and Canada has increased over time. Interesting global linkages in crustacean competiveness are evident from the study. There is unidirectional causality from Canada to India's RCA and Canada to Ecuador's RCA. Further, the unidirectional causality is observed from Indian crustacean export to RCA India. India can reap further gains through further competitiveness enhancement and strengthening international market intelligence efforts. The export of crustacean products holds tremendous importance as the country is the prime exporter in the world in this category. Improving the competitiveness in this category would further help enhance the Indian exports and strengthen its global presence. It is needed that India keeps investing in R&D and innovative technologies for quality improvement and sustaining its RCA in long run.

Statistics and Computer Applications

Statistical methodologies/tools/techniques developed and updated

Variance balanced structurally incomplete row-column designs: Methods of construction for obtaining pairwise and/or variance balanced SIRC (structurally incomplete row-column)/BILS (balanced incomplete latin square) designs were obtained. An R code for generating the information matrix given the layout of a design was also developed.

Network designs for agroforestry: In agroforestry experiments, different species of trees may interact spatially, and experimental plots may be connected through a network of trees which would create non-directional adjacency effects on a plot and give rise to Tree network effect on the crop. A class of variance balanced network designs for the estimation of direct as well as network effects of trees from adjacent plots has been obtained.

High dimensional genomic data: Proposed an

efficient approach for detecting outlier in high dimensional genomic data; the approach is p-value based combination methods to produce single p-value for detecting the outliers. Robustness of the approach was tested using simulated data through the evaluation measures like precision, recall, etc. Significant improvement in the performance of genomic prediction was obtained by detecting the outliers and handling them accordingly through our proposed approach using real data.

Non-parametric statistical tools for genomic selection: Genomic selection (GS) is the most prevalent method in today's scenario to access the genetic merit of individual under study. Impact of genetic architecture on genomic prediction accuracy was explored and comparative performance of the few most commonly used non-parametric methods for complex genetic architecture i.e. non-additive, was evaluated using simulated dataset generated at different level of heritability and varying combination of population size. Among several non-parametric methods, SVM outperformed across a range of genetic architecture.

Machine-learning algorithm for classification models: Developed, a novel machine-learning algorithm called Multi-Branch Ferns (MBFerns) to build multi-branch ferns (multi-branch decision tree) and to generate key features from training dataset employing Naïve Bayesian probabilistic model as a classifier. The proposed algorithm performs well for general classification problems and extracting actionable knowledge from training data.

Hybrid models for identification of DE-genes: Developed a new hybrid model (NBPFCROS) for the identification of DE-genes (differentially expressed). The NBP model based on compound mixture of Poisson-Gamma distribution is used as a parametric statistic and fold-change value derived using fold-change rank ordering statistics (FCROS) algorithm is used as non-parametric statistic. The performance of NBPFCROS model was compared with NBP, FCROS, edgeR and DESeq2 models using synthetic and real RNA-Seq datasets, and the developed model NBPFCROS was found more robust compared to other models.

Trend free partially balanced incomplete block designs: In agricultural, animal, fisheries and industrial experimentation under block design setup, systematic trend may affect the response under consideration. Considering this, a method of constructing classes of trend free partially balanced incomplete block (TR-PBIB) designs based on different association schemes were developed. For providing readymade solutions to the end users, SAS macros for the generation of such designs were also developed and made available in public domain.

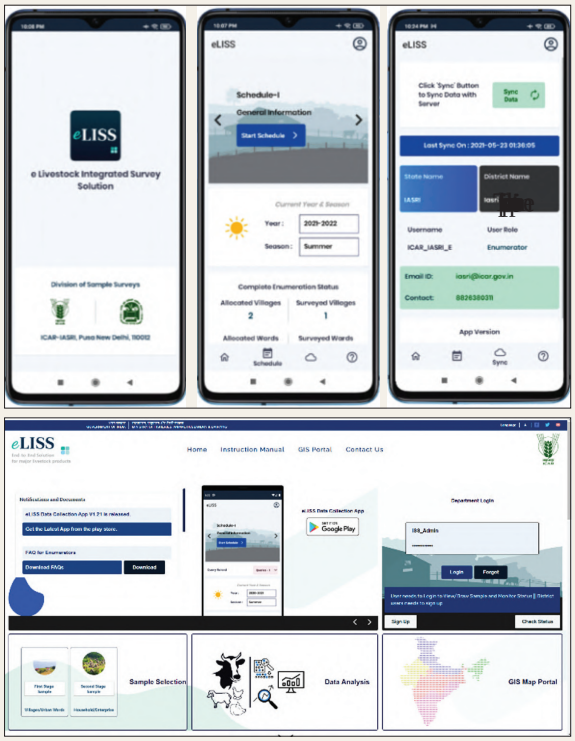
Sampling methodologies: (i) Different methodologies for the commodity groups and corresponding three guidelines for the estimation of post-harvest losses of fruits and vegetables, livestock (meat and milk) and fish products, were developed. These were accepted by FAO, Rome, for adoption, and were field tested in Mexico, Zambia, Nepal and Thailand. (ii) Sampling methodology for 2019/20 Lao Agriculture Census was developed, which was recommended and adopted by FAO for conducting Agriculture Census and generating estimates for parameters of interests for Lao, PDR. This methodology consists of Village component, Complete Enumeration component, and Sample component. A suitable sampling strategy was proposed for Sample Component and estimation procedure was developed as per the proposed sampling strategy. The developed estimation procedure includes calculation of sample weights, effect of non-response and obtaining estimates along with standard errors.

Detection of outliers: Statistics were developed for detection of outliers in presence of masking in survey weighted regression. A calibrated estimator was developed for outlier imputation when auxiliary variables are available in sample surveys. The R code was written

Mobile Apps developed

Integrated Sample Survey Solutions for Major Livestock Products

An android-based application-eLISS data collection app was developed and is available on google play store to capture data from the field, which was collected manually using paper-based schedules by the enumerators. All the eight schedules of Integrated Sample Survey (ISS) scheme are captured by the app. This data collection app also selects second stage sample of households/enterprises in the selected villages/urban wards. The data captured through this app is to be synced to server. The major feature of the app is that it records the location at which data were collected, provides real time monitoring and offline data collection.



R-packages developed

- **TEnGExA:** Classifies the user provided gene lists into tissue-enriched or tissue-specific transcripts along with other standard classes.
  GitHub repository—URL: https://github.com/ubagithub/TEnGExA/
  GUI web interface is accessible at—http://webtom.cabgrid.res.in/tissue_enrich/
- **MSGARCHelm**: Hybridization of MS-GARCH and ELM Model—https://cran.r-project.org/web/packages/MSGARCHelm/index.html
- **SBAGM**: To Search Best ARIMA, GARCH, and MS-GARCH Model—https://cran.r-project.org/web/packages/SBAGM/index.html
- **eemdTDNN**: EEMD and Its Variant Based Time Delay Neural Network Model for forecasting univariate time series with different decomposition based time delay neural network models—https://CRAN.R-project.org/package=eemd TDNN
- **EEMDelm**: Ensemble Empirical Mode Decomposition and Its Variant Based ELM Model for forecasting univariate time series with different decomposition based Extreme Learning Machine models—https://CRAN.R-project.org/package=EEMDelm
- **EMDANNhybrid**: Ensemble Machine Learning Hybrid Model to fit Empirical Mode Decomposition and Artificial Neural Network based hybrid model for non-linear and non-stationary time series data—https://CRAN.R-project.org/package=EMDANN hybrid
- **ECTTDNN**: Co-integration Based Time-delay Neural Network Model to make use of the information extracted by the co-integrating vector as an input in the neural network model—https://CRAN.R-project.org/package=ECTTDNN
- **MARSANNhybrid**: Multivariate Adaptive Regression Spline (MARS) Based ANN Hybrid Model helps in selecting important variables using MARS and then fits ANN on the extracted important variables—https://CRAN.R-project.org/package=MARSANNhybrid
- **MARSSVRhybrid**: MARS SVR Hybrid helps in selecting important variables using MARS and then fits SVR on the extracted important variables—https://CRAN.R-project.org/package=MARSSVRhybrid
- **EMDSVRhybrid**: Hybrid Machine Learning Model to fit Empirical Mode Decomposition and Support Vector Regression based hybrid model for non-linear and non-stationary time series data—https://CRAN.R-project.org/package=EMDSVRhybrid
- **grapesAgril**: As Collection of Shiny Apps for simple Agricultural Research Data Analysis has been developed—https://cran.r-project.org/web/packages/grapesAgri1/index.html

for evaluation of developed methodologies.

Analysis of high-dimensional-gene-set-data: ICAR-IASRI proposed an innovative statistical approach and tool, namely GSQSeq (Gene Set analysis with QTL sequences), to analyze gene sets with genetically rich trait data, such as QTL which is an improvement over the existing GSVQ and GSAQ (Gene Set Analysis with QTL) methods, as it considers the DE (differentially expressed) scores of the genes in the gene list in performing GSA with the QTLs. In GSQSeq approach, the statistically meaningful and biologically interpretable p-values are assigned to each gene set, which profoundly describes the trait enrichment of the gene sets. Developed a package GSQSeq that is available in https://github.com/sam-uofl/GSQSeq. This software can analyze the gene sets for GE datasets derived from expression studies including microarrays and RNA-seq. For microarray GE data, four different gene selection methods, such as t-test, F-score, Maximum Relevance and Minimum Redundancy (MRMR), and Support Vector Machine (SVM) techniques, are implemented for the selection of relevant gene sets from the high-dimensional GE data.

Analysis of single-cell RNA-sequencing data: A novel statistical approach for various analyses of the scRNA-seq Unique Molecular Identifier (UMI) counts data, was developed. The various analyses include modelling and fitting of observed UMI data, cell type detection, estimation of cell capture rates, estimation of gene specific model parameters, estimation of the sample mean and sample variance of the genes, etc. Besides, the developed approach is able to perform differential expression, and other downstream analyses that consider the molecular capture process in scRNA-seqdata modelling. Here, the external spike-ins data can also be used in the approach for better results. Its unique feature is that it considers the biological process that leads to severe dropout events in modelling the observed UMI counts of the genes.

Biological Databases/Webservers/Algorithms developed

- A machine learning-based method for prediction of GIGANTEA proteins was developed. Based on the proposed model, the web server "**GIpred**" was established—http://cabgrid.res.in:8080/gipred.
- Black Pepper Drought Transcriptome Database (**BPDRTDb**), is freely accessible for academic use at http://webtom.cabgrid.res.in/bpdrtdb. This transcriptome characterizations of black pepper genotype and its web resource will serve as valuable resources for new genes discovery as well as developing SSR markers in endeavour of higher crop production. Putative markers can also be a reliable genomic resource to develop drought tolerant variety for better black pepper productivity.
- Computer vision with deep learning is emerging as a significant approach for non-invasive and

KISAAN 2.0 (Krishi Integrated Solution for Agri Apps Navigation) App

The KISAAN 2.0 (Krishi Integrated Solution for Agri Apps Navigation) App, was envisaged to help e-agriculture and to drive smart phone based agriculture in India. This app integrates more than 300 Agricultural related apps developed by ICAR Institutes in an aggregator android mobile app. KISAN 2.0 was developed based on data being provided through Web services from ICAR Mobile App Gallery (KRISHI Portal) as is clearly shown in Architecture of Kisan 2.0 in Note # 3. The developing Institutes would provide data on KRISHI Portal and it would automatically be ported to KISAN 2.0. Therefore, any new application developed will be added to KISAN 2.0 and discontinued application would get removed from this mobile app. It was developed to make farming convenient for Indian farmer. KISAAN 2.0 app provides a single interface in multiple Indian languages for Indian farmers to access agricultural knowledge about crops, horticulture, livestock, fisheries, natural resource management, agricultural engineering, agricultural education and agricultural extension. This app will revolutionize the way how an Indian farmer avails information on advance agricultural technologies, seeds, varieties and livestock as per their requirement leveraging the accelerated Internet and smart phones penetration in our country.

Salient features

- Available in 12 regional languages.
- Subject-wise interactive dashboard.
- Includes 300+ Agri-Apps.
- Keyword based search.
- Option for switching language.

non-destructive plant phenotyping. Spikes are the reproductive organs of wheat plants. Developed an online platform, "**Web-SpikeSegNet** (http://spikesegnet.iasri.res.in)," based on a deep-learning framework for spike detection and counting from the wheat plant's visual images and digital image analysis. As spike detection and counting in wheat phenotyping are closely related to the yield, "web-SpikeSegNet" is a significant step forward in the field of wheat crop yield phenotyping and can be extended to the other cereal crops.

- Identified Single Nucleotide Polymorphism (SNP) related to four important traits of buffalo, i.e. milk volume, age at first calving, post-partum cyclicity and feed conversion efficiency. These identified SNPs have been compiled as database called "**SNPRBb**". The database is accessible (http://snprbb.icar.gov.in) through web and can be used in molecular breeding program of buffalo species.
- Developed a transcriptome database of seasonality associated genes of Carp fish, Rohu (*Labeo rohita* Ham) – "**LrSATDb**". This genomic resource contains candidate genes and regulating pathways along with putative SSR and SNP markers and is freely accessible for non-commercial use at http://webtom.cabgrid.res.in/lrsatdb. This resource can be used as research tool especially in the endeavour of optimizing reproductive efficiency and fish productivity. Further, it can also be of immense use in genome assembly and annotation of Rohu.
- Developed Water Buffalo (*Bubalus bubalis*) Mastitis Database (**WBMSTDb**), an open source and user-friendly web resource of targeted gene panels, which can be used for academic purposes in future mastitis association studies (http://webtom.cabgrid.res.in/wbmstdb). This will help to mine variants of targeted gene panels in buffalo for mastitis resistance breeding program in India and other countries in an endeavour to ensure improved productivity and the reproductive efficiency of water buffalo.
- Developed "**PlantSSRDb**" (http://webtom.cabgrid.res.in/plantssr/) for providing a standalone platform for the exploration of the SSRs from the expressed portions of the genome as well as online platform for mining the SSRs either from the transcripts or the NGS reads of the transcriptome. PlantSSRDb provides the SSRs information accompanied with the primer pair information for 439 plants species.
- "**TpGBNVDb**"-Thrips palmi transcriptome database (http://backlin.cabgrid.res.in/tpgbnvdb/) developed in response to groundnut bud necrosis virus, is an online relational database of Melon thrips (*Thrips palmi*) transcriptome catalogues the information pertaining to assembled transcripts, differentially expressed genes and the pathways.
- "**CsExSLDb**"- *Cucumis sativus* Extended Shelf-Life Database is an online relational database of cucumber (*Cucumis sativus)* transcriptome (http://backlin.cabgrid.res.in/csexsldb/) that catalogues the information pertaining to assembled transcripts, differentially expressed genes and the pathways. This database was developed by ICAR-IASRI in collaboration with ICAR-IARI and ICAR-NIPB.

Information systems/portals developed

- Designed and developed a "**BRICS agricultural research platform**" (http://barp.org.in) which allows officials of all BRICS countries to register and collaborate on various themes as per the objectives of BRICS 2020–2021 agenda. The platform allows users to download/upload multiple documents, create projects/events, upload pictures, ability to collaborate using discussion forums and dashboard for decision support system.
- Developed ICAR-AU-Grievance Redressal and Monitoring System for Agricultural Universities, which is an online platform (https://education.icar.gov.in/grms/GRMS.aspx) which primarily aims to raise grievances on admissions, fellowships, accreditation of universities and related matters by the students/faculty with ease

Gender sensitive agri-nutrition

Different nutrition enhancing technologies were evaluated in participatory mode among women farmers in Sankilo and Tentalpur villages of Nishintakoili block in Cuttack district of Odisha. Average demonstration yield of newly introduced rice varieties (6.2 tonnes/ha) was higher (56.2%) in comparison to existing farmers' practice with variety Puja. In dairy farming component, the adoption rate of feeding balanced ration supplemented with mineral mixture was found to be most preferable (62%), followed by fodder cultivation of perennial protein rich fodder (50%), chaffing of green fodder (42%) and feeding total mixed ration (38%). Under NASF project, gender gap indicators were identified and assessed using the SHEET (social-health-environmental-economic-technological) module from a sample comprising 40 farm families. The major areas of gender gap identified were–equally paid for the same amount of work done (82.5%) in social aspect; BMI (body mass index) of female is at par with recommended BMI (92.5%) in health and nutrition aspect; equal access, control over land and water' (72.5%) in environmental aspect; 'avail loan from financial institutions (87.5%) in economic, and knowledge in carrying out crop production and post-harvest activities (57.5%) in technological aspects, respectively. A three-tier approach for Gender Sensitive Agri-Horti cropping system model, was developed for livelihood upliftment, nutritional enhancement and entrepreneurship development. Highest benefit cost ratio of vegetables, was observed in Brinjal (3.41) followed by chili (3.20). In crop module the benefit ratio in paddy was highest in var. CR-Dhan 312 (2.46) followed by var. Pradhan Dhan (2.29) and var. Maudamani (2.25).

from anywhere and anytime. A 4-tier automated redressal process flow is built to act for speedy and favourable redressal of these grievances in a transparent and effective way. Automated notification system, real time monitoring and tracking of grievances by the complainant is also facilitated through the system.

- **"KISAN-SARATHI"**- System of Agri-information Resources Auto-transmission and Technology Hub Interface, is an Information Communication and Technology (ICT) based interface solution with an ultimate goal to an intelligent online platform for supporting agriculture at local niche with national perspective. This also intends 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. This has been launched during 93rd foundation day of ICAR on 16th July, 2021 to support the emerging need of multi-ways and multi-lingual communication among various agricultural stakeholders. This initiative will be implemented in phased manner by ICAR-Indian Agricultural Statistics Research Institute, Agricultural Extension Division, ICAR and Digital India Corporation, MietY, Government of India. Currently the services have been started in four major states of India, viz. Bihar, Madhya Pradesh, Maharashtra, and Uttar Pradesh.

Significant attainments showcased at country level

- The President of India, Shri Ram Nath Kovind virtually conferred the Indian Council of Agricultural Research, New Delhi with the 'Digital India Awards – 2020 (Ministry of Electronics and Information Technology (MEITY), Government of India)' under the *Open Data Champion category*. The ICAR was felicitated with the Gold Icon Award for its Research Data Management Portal. This portal is developed, strengthened, and maintained by ICAR-IASRI as lead centre in partnership with other Institutes. The Open Data Champion Award is to acknowledge the Ministries/Departments/ Organizations/States for proactive, timely and regular release of datasets/ resources through Web Services/APIs on the Open Government Data (OGD) Platform (https://data.gov.in) in compliance with the National Data Sharing and Accessibility Policy (NDSAP). The Indian Council of Agricultural Research is committed for organizing its knowledge and making it available to the fullest extent possible through Open Government Data Platform (https://data.gov.in) and its own Portal- KRISHI (Agricultural Knowledge Resources and Information System Hub for Innovations) Portal (https://krishi.icar.gov.in). The Portal has been developed by ICAR-IASRI as a centralized data repository system for Research Data Management in the Council.
- **ICAR Research Data Repository for Knowledge Management:** KRISHI-Agricultural Knowledge Resources and Information System Hub for Innovations Portal is serving as a gateway to online resources available at different ICAR Institutes to enhance visibility and easy access of digital outputs of ICAR Stakeholders. For each scientist, profile page has been developed. This profile page is linked to official email ID (icar.gov.in) and pulls data from different repositories such as Publications, Technologies, copyright, patents, varieties registered and varieties developed. Developed CMS based website for AICRP on Linseed.
- **Variety information system:** A workflow based application has been developed to provide details of all varieties released along with their important characteristics at one place and made available at https://krishi.icar.gov.in/varietytech/. At present information on 180 varieties developed by 10 Institutes is available in the information system.
- **Information system for AICRPs:** Developed Information System for AICRP on Linseed. All breeding experiments, pathology and entomology experiments to be conducted for the year 2021–

22 are generated along with randomised layout using the information system by AICRP on Linseed. Also updated the module of download and upload of data sheet for Factorial Experiments and Split Plot Design for Information Systems for AICRPs on Pearlmillet, Wheat, Sunflower.

- **ICAR IPR repository:** For providing single window access of all intellectual assets, viz. patents, copyrights and varieties registered under PPVFRA, developed version 2 of ICAR IPR Repository using Angular JS with CAS Spring webapp.
- Developed and released the video film of "Agricultural University-Clean and Green Campus Awards" by Prime Minister in VC conference on 28th September 2021 (https://nahep.icar.gov.in/greencleancampus). Online applications of these awards were received and processed through the Clean and Green portal developed by ICAR-IASRI. A booklet entitled "Strengthening the Agriculture Education through Digital Interventions" along with Agriculture Experts Information System (AEIS) (https://aeis.icar.gov.in) and Management System for StudentREADY were also released during the VC Conference.
- **Virtual classroom and Agri-Diksha web education channel**: The new paradigm of digital learning in agricultural education system has been established at 18 Agricultural Universities across India by ICAR-IASRI under the aegis of NAHEP. This was inaugurated by Union Minister for Agriculture and Farmers Welfare, Rural Development and Panchayati Raj. Virtual classroom is an online space that simulates a live classroom for students and faculties. Agri-DIKSHA web channel is an interactive portal for facilitating teachers to develop and broadcast virtual learning modules and students stand to benefit from lectures delivered through video capture, quick access to high quality video repository and anytime, anywhere accessibility through laptop or mobile. Virtual classrooms are equipped with Digital Podium; Interactive Panel connected to the PC with options to write digitally; Visualizer with optical zoom features and Tracking camera with inbuilt AI (artificial intelligence) technology.
- Union Minister of Agriculture and Farmer's Welfare inaugurated "Poshan Vatika Maha Abhiyan & Tree Plantation" at all the KVKs/Institutes/AUs on the occasion of Prime Minister's 71st Birthday. ICAR-IASRI has designed and developed a portal "Plant Trees" (https://planttrees.icar.gov.in) which provides a unified platform for KVKs/Institutes/AUs to record the number of trees planted, upload images of the events and record any other key information about the event.

Drudgery reduction and vulnerability

Stripping the pod from the vines of the crop and decorticating of the pods is a laborious activity. Under AICRP on Ergonomics and Safety in Agriculture, a groundnut stripper was developed and tested for 20 hours as per the "Test code for power thresher for groundnut" with essential modification. The designed machine works in two modes, viz. stripping operation and decorticating operation.

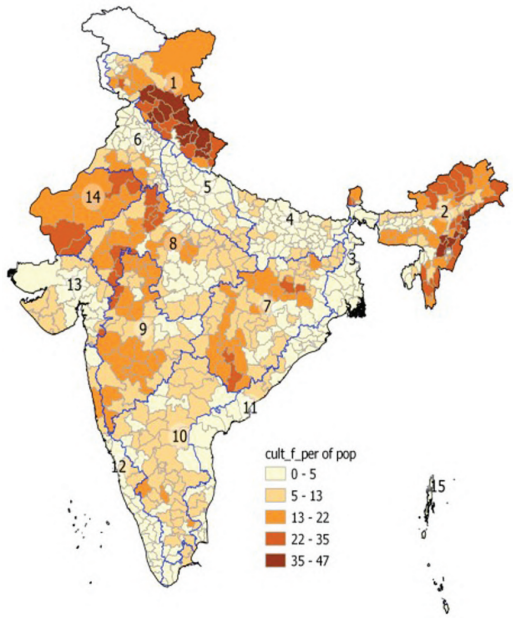
For farm women a manual disc ridger was also developed and tested for operational parameters to form ridges and channel with proper work rest cycle. The output capacity is 427 m^2/h, which is more than 5 times the traditional method of using spade. The walking speed of the subject is 1.78 km/h.

Empowering farm women

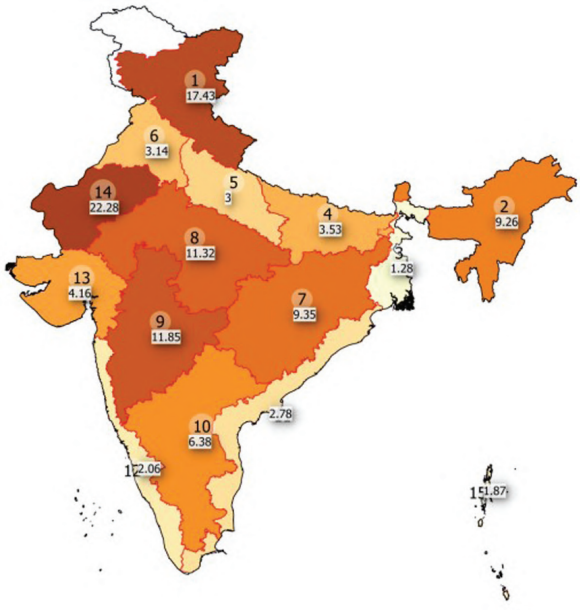
ICAR-Central Institute for Women in Agriculture (CIWA), Bhubaneswar carries out action research programmes on diverse aspects of women in agriculture. ICAR-CIWA has a mandate of undertaking research on gender issues in agriculture and allied fields, gender-equitable agricultural policies/ programmes, responses and coordinating research through its AICRP centres spread across 12 states in India. Various research and extension based activities are carried out through in-house, inter-institutional, network or collaborative and coordinated modes of research. During the reporting year the ICAR-CIWA carried out research activities focussing on farm women nutritional security, livelihood enhancement, technological empowerment, drudgery reduction and entrepreneurship development.

Women in agriculture database: Women's involvement in agriculture is diverse. The sectoral contribution of farm women indicated that the highest female agricultural workers as per cent of population (>28%) was in agro climatic region (ACR) 7 and 14. A total of five ACR (7, 8, 9, 10, 14) had more than 20% female agricultural workers and five ACR (3, 5, 6, 12 and 15) lower than 10%. Similarly, as per cent of population female cultivators were highest (22.8) in Western dry region (ACR 14) followed by western Himalayan region (17.4). The gender knowledge system in agriculture portal was enriched with a dynamic database on state/district wise gender work participation in agriculture.

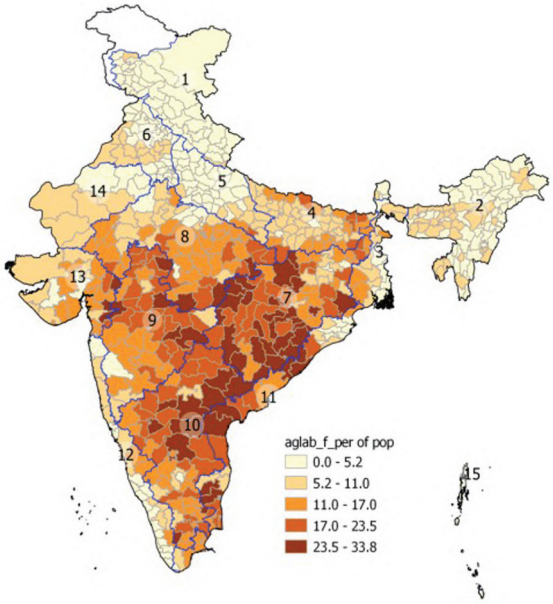
Enterprenurship and skill enhancement of farm women: Under the ICAR-CIWA-IRRI collaborative project a Women Farmer Producer Company named "Chitri Dora" was formed with the help of guarantee partner PRAGATI at Koraput involving 1,031 tribal women farmers, covering 30 producer groups, for collective marketing of aromatic rice. A rubber sheller rice processing unit was established in B. Ghatarla village



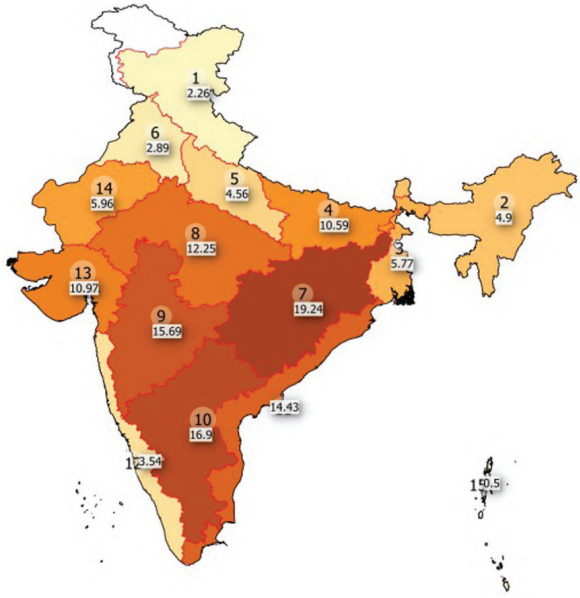
Distribution of female cultivators across districts in India



Distribution of female cultivators in 15 agro-climatic regions of India



Distribution of female agricultural labourers across districts in India



Distribution of female agricultural labourers in 15 agro-climatic regions of India

District wise Work Participation in Agriculture (India)

A. Work Participation (Number)

Year of Census	Select Year	--- Choose one ---
State	Select State	--- Choose one ---
District	Select District	
Population	Type of Population	--- Choose one ---
Area	Select Rural/ Urban /Total	--- Choose one ---

SUBMIT

B. Work Participation in Agriculture (Percentage)

Year of Census	Select Year	2011 Census
State	Select State	ORISSA
District	Select District	All District
Population	Type of Population	Population involved in Agricultur
Out of/ per		Out of Total Workers
Area	Select Rural/ Urban/ Total	Rural

SUBMIT

Searchable dynamic database on district-wise work participation in agriculture (https://icar-ciwa.org.in/gks/index.php/information-and-statistics-section/142-districtdata)

Rice processing unit by tribal farm women

of Kotpad block in Koraput district and 5 members of the producer company were trained on operation of the rice processing unit. Under the entrepreneurship development programme with fisheries, participation of rural women in four villages of Satyabadi block, Puri district was taken up with the technology of polyculture of Indian major carps with small indigenous fishes in homestead ponds. Skill based capacity development of 200 fisherwomen of SHGs, Puri was imparted on value addition of fish in entrepreneurship mode and 40 master trainers were trained from 17 SHG groups. The market linkage was ensured with Mission Shakti, Odisha through digital technologies like e-banking, e-commerce and social media. The value added products were also displayed through the marketing website bikayi.com under the trade name Fishlikes. Market linkage of rural women SHGs was strengthened with Falcon Chilka Fresh retail outlets in Bhubaneswar for their economic empowerment. The family poultry production model was implemented in a cluster of 40 farm families in Chanrapada and Parichanrapada villages of Nimapada block of Puri district, Odisha with the objective of enhancing income and improving nutrition security of farm families. The average net income was increased by ₹750–800/household in the farming system. Farm women also played an important role in marketing of eggs and chicken at their doorstep. Under the extra-mural project three major sectors, viz. horticulture, dairy and farm implements for establishing institute-industry-women farmers' linkage was established. Two industries, each in dairy sector (OMFED and Milk Mantra); horticultural sector (Art of organic and Kamal Enterprise) and farm implements sector (UNICUS and Sai Shakti Industry) were linked with the institute.

Disc type ridger for farm women

All India Coordinated Research Project (AICRP) on Women in Agriculture: Under AICRP (WIA) centres at 13 Agricultural Universities in 12 states across the nation, a total of 362 foods from different food groups having low Glycemic Index (GI) for addressing non-communicable diseases such as diabetes were documented and a database on low glycemic index foods for the management of diabetes was prepared. The products of high fibre multigrain mix were formulated from locally available cereals, millets, pulses and other functional food ingredients (FFIs) for management of over-nutrition/obesity. Two MoU were signed by ICAR-CIWA and AICRP Centre UAS, GKVK, Bengaluru for commercialization of high fibre food mix. The art forms were digitized to suit textile designing with the arts and principles of design. A Patent was filed on "Biodegradable Mesta Composite Pots for Nurseries" invented by UAS, Dharwad centre. Farm Women Knowledge Groups (FWKGs) were promoted for enhanced use of ICT in Agriculture and Allied Sectors and data were collected from 1,100 farm women and 1,100 rural men from eleven centres. To enhance the use of ICT tools in agriculture and allied activities, viz. capacity building programmes were organized. Linkages were also developed with government and non-government departments to organize interventions/ programmes/ trainings/ exposure visits, etc. for the benefit of FWKGs members.

Low glycemic index regional food Nirog atta (ready to use high fibre flour)

All the centres identified one to three technologies related to Agriculture and allied areas, Animal husbandry and Home science as interventions. These packages were validated and tested by specialists for their effectiveness. The data on knowledge of 1,100 rural women regarding causes of climate change was collected to find out whether they know the factors responsible for climate change. Based on the constraints faced by the farm women owing to the effects of climate change different region specific climate interventions based on community specific, farm specific, livestock specific and household specific were provided. ❑

13. Information, Communication and Publicity Service

The ICAR-Directorate of Knowledge management in Agriculture (DKMA) is mandated to showcase ICAR's technologies, policies and other activities through latest dissemination methods that cater to diversified stakeholders in the field of agriculture. In the fast changing knowledge intensive era, the DKMA is committed to promote ICT-driven technology and information dissemination system for quicker and more effective outreach. The ICAR-DKMA publishes periodicals, books, handbooks, Annual Reports, newsletters, bulletins, monographs, e-books, media columns, social media contents, advisories, etc. The knowledge banks are available in open access as well as in closed access models to the stakeholders in agriculture. ICAR-DKMA has already taken steps to disseminate knowledge by using up-to-date most popular ICT tools for benefitting the national as well as global agricultural world. The Directorate makes sincere efforts to take the knowledge through mass media for enhancing the knowledge of the people. ICAR-DKMA maintains knowledge in the Library Management and Open Access National E-Library on Agriculture (e-Pubs).

Knowledge and information products

The e-Pubs platform being maintained by ICAR-DKMA hosts around 46 journals having a total tally of 5,28,574 users. *The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*, the monthly research journals of international repute have been put on the open access mode (http://epubs.icar.org.in/ejournal). The journals have a wide clientele and received a total of 1,865 (*The Indian Journal of Animal Sciences*) and 2,794 (*The Indian Journal of Agricultural Sciences*) submissions, respectively during the reporting period. The user base of the journals have expanded—2,125 and 3,273 new users have associated making the total tally to 21,154 (*The Indian Journal of Animal Sciences*) and 40,926 (*The Indian Journal of Agricultural Sciences*) users. The journals website was visited nearly 45,000 times with audience belonging to 123 countries. The journals have considerable metrics, viz. impact factor and H index are 0.22 and 26 for *The Indian Journal of Agricultural Sciences* and 0.21 and 22 for *The Indian Journal of Animal Sciences* given the fact that these are multi-disciplinary in nature.

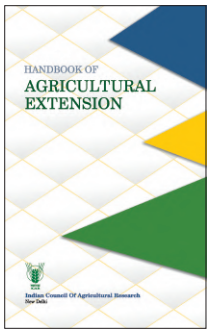
Status of ICAR-DKMA Journals

Parameters	Indian Journal of Agricultural Sciences	Indian Journal of Animal Sciences
Articles received	2,794	1,865
Total users	40,926	21,154
New users	2,125	3,273
Impact factor (Scimago)	0.22	0.206
Impact factor (Web of Science)	0.208	0.278
Impact factor (Scopus)	0.396	0.378
H index (Google)	26	22
Total visits	45,000 (123 countries)	

Popular periodicals like *Indian Farming* and *Indian Horticulture* were brought out on topical issues for outreach to the masses. Special issue of Indian Farming were brought out on varied themes like Agribusiness Incubation, Rice Special on completion of 75 Years of National Rice Research Institute, Transformation of Agriculture Scenario in view of the Recent Farm Bills, success stories of Farmer FIRST Programme and Agri-Innovations to combat Food and Nutrition Challenges presented at the Indian Agronomy Congress 2021. A Mango special issue and an issue dedicated to the International Year of Fruits and Vegetables formed the part of special issue series of *Indian Horticulture*. Indian Farming (monthly) and Indian Horticulture (bi-monthly) are also available online and digital copies of old issues can be accessed free of cost under open access policy.

Under the Textbook Publication Program of the English Editorial Unit, 5 new titles were published specifically designed for the undergraduate and postgraduate students of the agricultural universities with special reference to Indian context. These titles namely Textbook of Food Engineering, Managing Salt Affected Soils for Sustainable Agriculture, Practical Manual on Protocols and Methodology in Wheat Rusts

Research, Theoretical Concepts of Statistics in Animal Sciences and Computer Applications and Radioisotopes in Soil and Plant Studies were released on ICAR Foundation Day celebrated on 16 July 2021. Other books, viz. Principles of Landscape Gardening, Techniques in Parasitology, and Safe and Judicious Use of Pesticides on Tomato were also brought out.



Handbook of Agricultural Extension was published, an authoritative and benchmark publication under Extension series.

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 the world over.

Hindi Editorial Unit has continued to play an important role in dissemination of information about the new achievements of agriculture research through the two popular journals, namely *Kheti* (Monthly) and *Phal-phul* (Bimonthly). During the reporting period, five special issues of the Hindi journal *Kheti* were brought out based on the themes of '*Fisheries*', '*Sugarcane*', '*Climate Change*', '*Nutrition and Food*', and '*Agriculture Innovation to Combat Food and Nutrition Challenges*'. Both the journals publish useful articles for the farmers, progressive farmers, agro-entrepreneurs and extension workers based on new innovations in agri-research and technologies for enhancing the income.

DKMA organized and facilitated two exhibitions for showcasing ICAR technologies and publications namely Pusa Krishi Vigyan Mela, New Delhi and XV Agriculture Science Congress, BHU, Varanasi. Achieved the revenue of approximately ₹ 63 Lakhs from the sale of publications and e-products during the year.

Social media

To disseminate information in real-time, the ICAR Website is updated on a regular basis and in total 4,589 pages were updated, and a total of 4,577,864 page views from more than 200 countries were recorded. Knowledge seekers across the globe visited the Website. The top five countries visiting the Website included India, United States of America, United Kingdom, United Arab Emirates and Nepal.

On ICAR Facebook page, a total of 430 posts were published during the year 2021, and it has 220,379 followers.

ICAR Twitter handle has more than 160,132 followers. On an average, 3 tweets are posted every day, and a total of 1,013 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.

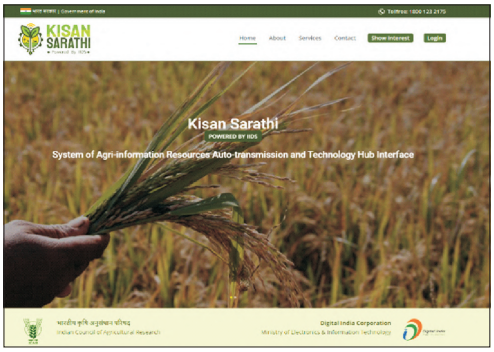
ICT Initiatives

ICAR DARPAN Dashboard (https://icar.dashboard.nic.in/login.aspx): This provides centralized, easy-to-access platform for display and access of data from multiple sources. In this Dashboard, Manual/real time data on Key Performance Indicators (KPIs) is presented for selected Schemes/Projects in tabular as well as in graphical format. The information flow related to agricultural extension is being integrated in real time basis. The data and related graphs can be accessed at the lowest grain level in terms of location and time.

Kisan Sarathi: In order to increase the penetration of agricultural technologies and two way effective communication with farmers, multi-media based multilingual ICT based communication system "Kisan Sarathi: An interface solution with farmers" has been launched on 93rd Foundation Day of Indian Council Agricultural Research jointly by the Honourable Ministers Shri Narendra Singh Tomar ji (Agriculture and Farmers' Welfare) and Shri Ashwini Vaishnawji (Information and

Launching of Kisan-Sarathi by the Honourable Ministers

Communication Technology), Government of India in the presence of Shri Parshottam Rupalaji, Minister for Fisheries, Animal Husbandry and Dairying and Shri Kailash Choudhary ji, Minister of State for Agriculture and Farmers' Welfare and Smt Shobha Karandlaje ji, Minister of State for Agriculture and Farmers' Welfare. The ultimate goal of this project is to implement an intelligent online platform for supporting agriculture at local niche with national perspective. The project is 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 of 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. Currently the services has been started in four major states of India, viz. Bihar, Madhya Pradesh, Maharashtra and Uttar Pradesh. At present, a total of 230 KVKs are enrolled with the system, where more than 800 subject matter experts are extending their advisory services to more than 8 Lakh farmers.



Kisan Sarathi

Agricultural Research Management System (https://arms.icar.gov.in): The Agricultural Research Management System (ICAR-ARMS) has been developed for evaluation, monitoring and management of scientific output for policy planning of the Council. Version 1.0 of this system was released on 19 March 2021 to input scientific achievements of each scientist from April 2021 onwards. This system will help in real time research assessment and its prioritization at different management levels, i.e. institute, SMD and the Council.

Screenshot of home page of ICAR-ARMS

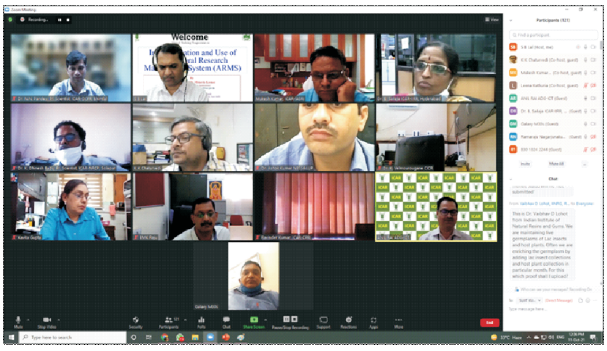
Some important features of this software are as follows:

- ARMS is a workflow-based system that can be accessed online (https://arms.icar.gov.in) using ICAR domain Email id credentials.
- The system will be used for evaluation, monitoring and management of scientific research based on the information submitted by scientists. Scientists will enter the information into the system only once, which would save the scientists' time to provide information many times for different requirements.
- Significant Achievements under broad categories (Research, Capacity Building, Publication and Peer Recognition) need to be entered by the scientist on regular basis. The information submitted by scientist is to be duly verified by Reporting Officer, Nodal Officer and Reviewing Officer.
- System will have provision to provide various information in report formats (Monthly progress report of Division/Institute/SMD/Annual report material of Institute).
- For more details, one can refer to the user manual (https://arms.icar.gov.in/Files/arms Manual_new.pdf) of the system. User can share the feedback using the inbuilt feedback proforma.

ARMS is being used by ICAR Scientists from April 2021 onwards for uploading their significant achievements in various categories on monthly basis and 2 virtual training programs for nodal officers on 8th June and 11th October 2021, and 4 webinars were organized to sensitize the users on 20 October, 22 October, 25 November and 2 December 2021 for scientists of ICAR. There was a question-answer session after completion of presentation and demo for all virtual trainings and webinars. A development and support team are working continuously for enhancement, modification and answer to queries from various scientists of ICAR.

e-HRMS (Human Resource Management System): It is a work flow based online solution which consists of creation of e-service book and all processes/ information impacting service book from joining to retirement of an employee. This system can be accessed online (https://ehrms.gov.in/EhrmsWebApp/home) by using ICAR domain email credentials. The Leave and LTC module of e-HRMS has been made operational for the use of all staff members of ICAR Headquarters on 15 July 2021 and 20 October 2021 respectively.

Land Record Management Information System (https://lrms.icar.gov.in): An online solution for Land Record Management of ICAR institutes was developed by IT Unit of IASRI in collaboration with ICT Unit of ICAR Headquarters and Director (Works). The information obtained from this system can be readily used for deciding the future policies for land management by the Council. The Land Record Management System (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),



Snapshot of virtual training programme on implementation of ICAR-ARMS

ownership description as per revenue record, date of possession as per revenue record, date of acquisition, free hold land/leased hold, lease period, start date for lease, date of renewal of lease etc. The requisite data is submitted by Institutes and the software generate advisory about expiry of lease (within one year). Similarly, advisory is also generated for updating the status of dispute/ court cases on quarterly period and sent to the Director of the institute, Administrate Head (Head of Office) and Director (Works). ❑

14.

Technology Assessment, Demonstration and Capacity Development

Krishi Vigyan Kendras (KVKs) are district level multidisciplinary scientific institutions for frontline extension mandated with technology assessment and demonstration for its application and capacity development under different farming situations across the country. In all, 5 new KVKs were established taking the total number of KVKs to 729 in the country during the reported year. 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

Technology assessment is among the core activities of KVKs, mainly for identifying the location specificity of agricultural technologies developed by National Agricultural Research System under various agro-ecological situations. The details of technologies assessed under different thematic areas of crops, livestock, enterprises and women empowerment are discussed below.

Crops: The KVKs assessed a total of 5,222 technologies of various crops at 12,015 locations through implementation of 25,843 trails at farmers' field under different thematic areas, namely cropping systems; drudgery reduction; farm machineries; integrated crop management; integrated disease management; integrated nutrient management; integrated pest management; integrated weed management; processing and value addition; resource conservation; storage techniques; and assessment of newly released varieties of cereals, pulses, oilseeds, fruits, vegetable and commercial crops. Varietal evaluation was the major theme of technology assessment with 1,476 technologies assessed through 6,680 trials. Integrated nutrient management (787 technologies, 3,998 trials, 1,671 locations) and integrated pest management (766 technologies, 3,919 trials, 1,449 locations) were the other major thematic areas on which technology assessment was carried out.

Livestock: A total of 873 technological interventions pertaining to different livestock were assessed by KVKs at 3,204 locations through 6,646 trials covering thematic areas such as animal disease management; evaluation of breeds; feed and fodder management; nutrition management; livestock production management; as well as processing and value addition. Nutrition management was the major thematic area with 220 technologies and 1,959 trials at 576 locations. All the major livestock species like cows, buffalo, sheep, goat, poultry, pig and fish were covered under the technology assessment.

Other enterprises: KVKs tested 364 technologies at 1,222 locations through 2,247 trials under other enterprises including mechanization; processing and value-addition; drudgery reduction; small-scale income generation; nursery raising; fish production and management; and household food security. Mechanization was the major thematic area with 122 technologies assessed at 98 locations through 682 trials. Entrepreneurship development was the prime focus of all the technologies assessed.

Women empowerment: As part of technology assessment, 299 technologies related to farm women were assessed through 2,077 trials at 579 locations. Health and nutrition (technologies 84, trials 513, locations 89) and drudgery reduction (technologies 67, trials 489, locations 58) were the major technologies assessed with an aim to promote women empowerment.

Frontline Demonstrations

Cluster Frontline Demonstration

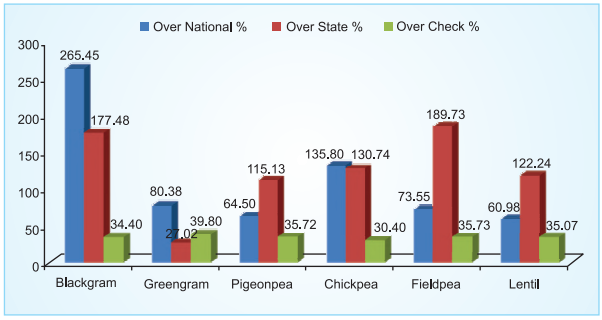
A detailed programme was planned, prepared and executed by Division of Agriculture Extension, ICAR, New Delhi on Cluster Frontline Demonstrations (CFLDs) with funding support under NFSM, Department of Agriculture and Farmer Welfare, GoI, New Delhi with an objective to demonstrate the production potential of improved production and protection technologies of major pulse (chickpea, pigeon pea, lentil, blackgram and greengram) and oilseed (sesame, groundnut, linseed, soybean, mustard, sunflower) crops in the country. Analysis of district specific production constraints, preparing technology modules for each district, knowledge and skill up gradation of identified KVKs and extension workers, and regular monitoring have been the key components of this programme.

Cluster Frontline Demonstration on Pulses: A total of 52,260 CFLDs on different pulse crops were organized covering 19,784.53 ha area (7,014.72 ha area and 17,946 demonstrations in *kharif*, 9,106.81 ha area and 26,505 demonstrations in *rabi* and 3,663 ha area and 7,809 demonstrations in summer).

Yield advantage through CFLDs of various pulse crops

CFLD on chickpea (NBeG 49) KVK, Gadag

CFLD on blackgram (Shekhar-2) KVK Kaushambi

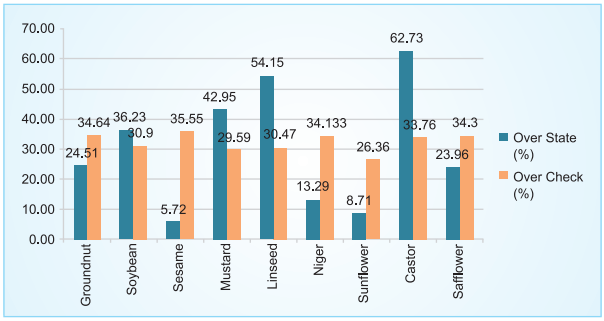


Yield advantage through CFLDs of various pulse crops

over national, state and check yield was significant. In blackgram, yield advantage through cluster frontline demonstrations over the national, state and check yield was 265.45, 177.48 and 34.40%, respectively; in greengram 80.38, 27.02 and 39.80%; and in pigeon pea 64.50, 115.13 and 35.72%, respectively. Likewise, significant yield advantage recorded through cluster frontline demonstrations was 135.80, 130.74, 30.40%, in chickpea; 73.55, 189.73 and 35.73% in field pea; and 60.98, 122.24 and 35.07% in lentil over national, state and check yield, respectively.

Cluster Frontline Demonstration on Oilseeds: In all, 74,754 CFLDs on different pulse crops were organized covering 29,955.20 area (7,157.60 ha area and 17,740 demonstrations in *kharif*, 19,568.60 ha area and 48,711 demonstrations in *rabi* and 3,229.00 ha area and 8,303 demonstrations in summer).

Yield advantage through CFLDs of various oilseed crops over state and check yield was significant. In groundnut crop yield advantage through cluster frontline demonstrations over the state and check yield was 24.5 and 34.64%. The yield advantage was 36.23 and 30.9% in soybean; 5.72 and 35.55% in sesame; 42.15 and 29.59% in mustard; 54.15 and 30.47% in linseed; 13.29 and 34.13% in niger; 8.71 and 26.36% in sunflower; 62.73 and 33.76% in castor, and 23.96 and 34.3% in safflower over state and check yield, respectively.



Yield advantage through CFLDs of various oilseed crops

Frontline Demonstrations on crops other than oilseeds and pulses

A total of 167,026 Frontline Demonstrations (FLDs) other than CFLDs including 103,217 FLDs on crops covering 20,047.84 ha area, 18123 demonstrations on farm machineries covering 8,639.96 ha area, 17,524 FLDs on livestock and fisheries, 20,252 demonstrations

Mustard variety RH-749 in KVK SHUATS, Prayagraj

Groundnut variety (TG 51) in KVK Jalpaiguri

SUCCESS STORY

Protected cultivation of cut-carnation flower (KVK, Solan)

Shri Vikrant Thakur belonging to Kothi village block Solan of Himachal Pradesh used to cultivate flowers like rose, chrysanthemum, hydrangea, and exotic vegetables in his polyhouse since 2009 in 300 m^2 of area. He was not able to get good income. He shifted to Carnation (*Dianthus caryophyllus*) with the support of financial institutions under the technical guidance of KVK, Solan in 2013. Now the farmer has brought 10,000 m^2 of area under carnation and has become an inspiration for the young farmers. He is following modern technologies like application of GA_3 100 ppm after first pinch and when axillary shoots are 8–10 cm in length, drip irrigation, mulches, soilless media, growing bags etc. He is producing on an average 37 lakh cut stems/ha and earning approximately about 30 lakh from the cultivation of carnation per year. He has built rain water harvesting structures by making small poly-lining ponds. Now the farmer is self-sufficient and storing 85 lakh litres of water for the cultivation of flowers in polyhouse. He has permanently employed 15–16 local workers to carry out all the cultural operations in cultivation of flowers. He has been guiding many youths of the district.

A view of carnation under polyhouse of Shri Vikrant Thakur

on other enterprises and 7,910 FLDs on gender-specific technologies for women empowerment, were organized.

Cereals: Among cereal crops, 10,684 FLDs were conducted on 5,886 technology options of wheat varieties and management technologies in 3,518 ha area by 284 KVKs. The Average yield in the demonstrations was 12.0% higher than the farmer's practice. A total of 3,963 varietal and technology options were demonstrated in 13,443 FLDs in 4,968.1 ha area on rice varieties and technologies by 394 KVKs in which the average yield in demonstration was 21% higher than the farmer's practice. On maize varieties and technologies, 142 KVKs conducted 3,344 FLDs on 902 varietal and technology options in 1,165.1 ha area wherein the yield increase was 17% in the demonstrations over farmers' practice. Demonstrations (1,096) were also conducted on barley and oats in 577.44 ha area. Thus, 28,567 FLDs on different cereals were conducted in 10,228.64 ha area.

Millets: In all, 2,943 FLDs on different millets were conducted in 838.20 ha area. Among the millets, the highest number of 453 varietal and technology options were demonstrated on finger millet by 45 KVKs in 1,251 FLDs wherein the average yield was 29% higher than the farmer's practice. Varieties and technologies on pearl millet (153) and barnyard millet (196) in 588 and 214 FLDs showed 25 and 26% higher average yield, respectively, than farmers' practice.

Pulses (other than CFLDs): Among 10,608 FLDs on 1,783 varietal and production technologies on pulses in 3,378.71 ha area, 2,729 FLDs were on chickpea (24% higher average yield than farmers' practice), 1,471 FLDs on green gram (30% higher average yield than farmers' practice), 234 on rajmah (35% higher average yield than farmers' practice), and 1,933 were on blackgram (33% higher average yield than farmers' practice).

Oilseeds (other than CFLDs): Out of a total of 14,913 FLDs on oilseed crops in 4,474.71 ha area, 7,742 FLDs were conducted on 2,421 varieties and management technologies of mustard, brown sarson, gobhi sarson, toria and rapeseed wherein the average yields were 28, 39, 17, 37 and 44% higher than the farmers' practice, respectively. A total of 1,644 FLDs were on soybean, 3,070 on groundnut, 995 on sesamum and the average yields were 23, 22 and 29% higher than the farmer's practice.

Horticultural crops: Altogether, 31,532 FLDs were conducted on 5,965 varieties and technologies of horticultural crops in 6,583.32 ha area comprising vegetables (15,694), fruits (3,822), flowers (556), spices and condiments (3,442), medicinal and aromatic crops (106) and plantation crops (5,920). The increase in average yields recorded in demonstrations as compared to farmers' practice was 31.6% in vegetables, 38.5% in fruits, 26.3% in flowers, 29.5% in spices and condiments, and 26.2% in tuber crops over the farmers' practices.

Commercial crops: A total of 1,456 FLDs in 546.57 ha area including 561 FLDs on sugarcane were conducted by KVKs. The average yield increase in the demonstrations plots was 15% in sugarcane as compared to farmers' practice.

SUCCESS STORY

Dsb-21—a new soybean variety disseminated

KVK Belgavi-II of Karnataka demonstrated a new variety Dsb-21 of soybean in the year 2015–16, which is resistant to rust and tolerant to pod shattering at Chikkabagewadi, Mattikopp, Sampagaon and Deshanur villages of Bailhongal taluk by involving 160 farmers covering of 67.40 ha. KVK imparted training to farmers on package of practices. The area has been expanded to 650 ha under Dsb-21 variety with production of 13,000 q.

A view of field performance of soybean variety Dsb-21

Fibre crops: In all, 1,400 FLDs in 565.03 ha area including 1,018 FLDs were conducted on cotton varieties and technologies wherein the average yield was 17.0% higher than the farmer's practice.

Fodder crops: Demonstrations on crops such as berseem, maize, sorghum, Napier grass, etc., were conducted in 3,097 farmers' fields covering an area of 421.3 ha. The average yields in demonstrations were 41.25% higher than the farmer's practice.

Hybrids: To achieve higher harvest index in crops, KVKs conducted 8701 FLDs on 1573 hybrids covering an area of 2,494.4 ha in cereals, millets, oilseeds, pulses, fodder crops, commercial crops and horticultural crops. In cereals comprising rice and maize, 2,493 FLDs were conducted in an area of 942.5 ha to demonstrate the potential of various hybrids. Demonstrations on hybrids of oilseeds were conducted across the country covering 243 ha area. A total of 3,050 FLDs were conducted on various vegetables, fruits, flowers and spices in 479 ha area. In hybrid cotton 835 demonstrations were conducted in an area of 351.8 ha where the average yield increase was 16% over the farmer's practice.

Farm mechanization: A total of 18,123 demonstrations were conducted on 3,290 technology options on improved tools and farm implements including drudgery reduction technologies covering an area of 8,639.96 ha. The highest number of 5,835 demonstrations were on sowing and planting machineries and 4,111 on post-harvest processing 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 at 15,981 farmers, locations and 1,543 demonstrations were conducted on fisheries.

Enterprises: A total of 20,252 demonstrations on 20 enterprises like mushroom cultivation, apiary, sericulture, value addition, vermicompost, nursery etc., were conducted in which 42,324 enterprise units were established. On women and children, 7,910 demonstrations were conducted on various enterprises like value-addition, kitchen garden, nutrition etc.

SUCCESS STORY

Mushroom as successful enterprise under ARYA in Kokrajhar district of Assam

KVK developed entrepreneurship in mushroom production in Rangati village by training 22 youths during 2019–20. On completion of training five youth were selected and provided with inputs for establishing Mushroom production unit. Shri Rajib Baruah is one among them who started his mushroom production unit (oyster mushroom) with the inputs provided. In first year, he got a production of 7 q mushroom which he sold @ ₹ 180/ kg. He could get a return of ₹ 126,000. In second year, he got a production of 24 q mushroom which he

Establishing the entrepreneurial units of mushroom

Mushroom at blooming stage

sold @ ₹ 200/kg and got a return of ₹ 432,000. He invested his income for increasing the capacity of his unit. In addition to that he also started button mushroom cultivation. He also provides training to local youth as and when needed. Presently 4 youths have got full employment along with partial employment of 15 youths. He has also engaged several youths in his entrepreneurial unit thus, providing employment generation. His productions are mostly marketed to nearby state of Arunachal Pradesh as well as within and outside the district and also among the local small entrepreneurs. The mushroom production under ARYA has proved to be a successful enterprise for providing employment opportunity to the rural youth of the district.

SUCCESS STORY

Successful organic farming of tulsi, chia, kemuoil, piprata, shatavar

Shri Dhwaj Pal Singh, a progressive farmer belonging to Dadri village, Panwari block of Mahoba district was involved in traditional agriculture before 2005, which was not much profitable and ultimately, he decided to convert his agriculture into organic farming. Hence, he underwent training at KVK, Mahoba on different aspects of organic farming like preparation of vermi and NADEP compost, bio-fertilizers, jeevamrit, panchagvya, bio-pesticide and organic cultivation of cereals, oilseeds, pulses, medicinal and aromatic plants, etc. He started

growing tulsi/kemuoil/kinnowa/bhumiaonla/Chandra surya/chia seeds/shatavar and hibiscus flower in his 6.8 ha area by adopting organic farming under the technical guidance of KVK scientists. He constructed animal shed for stray cattle and poultry unit of Kadaknath breed. He is producing 1,000 q of vermicompost for organic cultivation of meditational and aromatic plants on his farm and produced organic tulsi, chia seed, kemu oil, piprata, shatabar, Chandra surya, pigeon pea, chickpea, mustard and wheat. The annual economic gain in terms of net return is ₹ 4.5 lakh. He has PGS organic certification from APEDA. He was awarded by the Organic India Company as Dharti Mitra Award and received award and appreciation from other organisations.

Capacity Development

A total of 18.31 lakh farmers/farm women, rural youth and extension personnel were trained on various aspects through 60,026 training programmes including the sponsored training courses for knowledge and skill up-gradation.

Farmers and farm women

The KVKs organized 45,469 training programmes on various technologies with participation of 14.46 lakh farmers and farm women out of which 4.66 lakh (33%) participants were from SC/ST category and 9.73 lakh (67%) were from other classes. These courses targeted productivity enhancement and cost reduction of field crops (21.33%), horticultural crops (16.30%), plant protection (13.12%), empowerment of rural women including home science (12.19%), livestock production and management (10.66%), soil health and fertility management (9.76%), capacity building for group actions (4.83%), agricultural engineering (3.95%), production of inputs (3.29%), fisheries (2.63%) and others including agro-forestry (1.96%). Out of these training courses 39.68% were organized on-campus, whereas rest (60.32%) were organized off-campus. Within field crops, integrated crop management was the leading theme in which 24.71% of courses were organized followed by

SUCCESS STORY

Woman farmer diversified her farm production for better returns

Mrs Harshada Rajendra Palaye, 38 years old woman and a resident of Kondye village in Lanja tehsil of Ratnagiri district was involved in family farming. She had an operational land holding of 4 ha. She was cultivating subsistence crops like rice, finger millet, horsegram etc. in the traditional way. She established a vermicompost unit under the technical guidance of KVK by availing subsidy of ₹30,000 for construction of shed (15×10 m) in the year 2010 from the Department of Agriculture, Government of Maharashtra. KVK also provided vermin-culture of earthworm *Eisenia fetida* for demonstration. At first she prepared vermi-compost unit of the capacity of 5–6 tonnes and sold it at nearby villages. Approximately, she earned ₹ 45,000–50,000 from this small-scale activity. She decided to expand her small-scale activity into a commercial business venture. She joined a Self-help Group named-Shri Samarth Shetkari Swayamsahata Gat consisting of five male and five female farmers. She sold vermicompost under trade name of this Self-help Group. The vermicompost prepared by this group is available in 1 kg, 5 kg, 10 kg and 40 kg poly bags. Now, Shri Samarth Vermicompost became a brand name among the farming community in the Konkan region. At present, she has reached to the production capacity of more than 100 tonnes per year. On an around, she has a turnover of ₹ 12–13 lakh/year out of this business venture. Year-round, she employed 7–8 people in Kondye village.

Woman farmer diversified her farm production

After getting a grand success in vermicompost production, Mrs Harshada moved to the idea of the ornamental nursery. Vermicompost is the main media for growing ornamental plants and the other reason behind starting ornamental nursery as per demand of ornamental plants in Mumbai for terrace gardening. Considering this opportunity, she has started ornamental, fruit and forest crop nursery. In the beginning, she prepared 1,000 vegetable seedlings and sold it out in the weekly market. After getting confidence, she constructed polytonal for preparation of grafts. Since last 3–4 years, she is producing about 10,000 grafts of cashew (Var. Vengule 4), 4,000 of mango (Var. Kesar and Alphonso), 1,000 coconut (Var. Banavali) and 500 kokum fruits crops. Addition to this, she is preparing about 2,000 rose and 5,000 Sonchaffa grafts and around 30,000 agroforestry crops, viz. teak, khair, sandalwood, bamboo, *Acacia mangium*, Aonla and gulmohar (*Delonix regia*). She is selling these grafts and seedlings under the same trade name of Shri Samarth Shetkari Nursery in entire Konkan as well as in western Maharashtra.

Mrs Harshada Palaye ensured economic stability to her family. Every year, her financial turnover is ₹ 13.50 lakh from vermicompost units and ₹ 19.75 lakh from the nursery unit. The net profit from vermi-compost is ₹ 6 lakh and ₹ 8.4 lakh from the nursery management. She is gaining profit of ₹ 14.04 lakh per year for her family. She has not only made her family a self-reliant but also provided assured employment for 10–12 persons throughout the year. Every employee is getting salary of around ₹ 7,000 to 8,000/month. Considering her contribution, Mrs Harshda Palaye and her SHGs was bestowed with 'Sevavrati Shinde Guruji Smruti Purskar (2019–20)' from Kunabi Seva Sangh, Dapoli- an NGO and 'Best Women Farmer Award' from NGO-Late Tatya Deshmukh Shetinitha Sanstha, Lanja, Dist, Ratnagiri.

seed production (9.59%),weed management (9.35%), cropping systems (8%), resource conservation technologies (6.61), integrated farming (6.11%), crop diversification (6.10%), production of organic inputs (4.70%), nursery management (2.53%), and water management (2.25%). Among the training courses on horticulture, vegetable crops constituted 64.55% while proportion of courses on fruits was 35.45%.

Rural youth

Training courses (9,937) for the skill development of rural youth were organized for 2.44 lakh participants out of which 79,157 (32%) were the young women during the period under report. The highest proportion of training courses under this category were imparted on mushroom production (10.33%) followed by value addition (7.47%), seed production (5.42%), vermi-culture (5.39), production of organic inputs (5.35%), integrated farming (5.23), bee keeping (5.11), nursery management of horticulture crops (4.41%), poultry production (4.01%), protected cultivation of vegetable crops (3.65%), sheep and goat rearing (3.30%), repair and maintenance of farm machineries and implements (3.01%), and dairying (2.68%). There were other areas on which relatively smaller number of training courses were organized for the rural youth. These trainings were conducted mainly on-campus (62.63%).

Extension personnel

Capacity development of 1.41 lakh extension personnel was carried out through 4,620 courses in the country. About 38.45% participants in these programmes were female. Different extension functionaries working both in government and non-government organizations for the development of agricultural sector in the country were included in these trainings. The training programmes mainly focused on agricultural technologies aiming at knowledge up-gradation in the area of productivity enhancement in field crops (12.77%), integrated pest management (10.54%), integrated nutrient management (8.29%), women and child care (7.40%), household food security (6.65%), protected cultivation technology (4.74%), production and use of organic inputs (3.77%), livestock feed and fodder production (3.72%), management of farm animals (3.27%), and capability building of ICT application (3.07%). Care and maintenance of farm machineries and implements, formation and management of SHGs, gender mainstreaming through SHGs, etc. were other areas under such training courses. Trainings for extension personnel were organised on-campus (44.95%) and off-campus (55.05%).

Sponsored training programmes

With a specialized focus, 4,885 sponsored training courses were organized for 1.67 lakh participants mainly comprising farmers, farm-women and rural youth and extension personnel. The women participants constituted 27.73% of the total in these training programmes. The sponsored programmes were mainly focussed on crop production and management (49.38%), livestock and fisheries (13.30%), home science (9.97%), agricultural extension (16.45%), farm machinery (3.50%) and miscellaneous (7.40%). Similarly, there were 2,568 sponsored training for vocational courses, which benefitted 64,284 rural youth of the country.

Extension programmes

KVKs organized 7.65 lakh extension programmes/ activities in the form of advisory services, diagnostic and clinic service, celebration of important days, exhibitions, exposure visit, ex-trainees sammelan, farm science club conveners' meet, farmers' seminar, farmers' visit to KVK, field days, film shows, group meeting, kisan goshthi, kisan melas, mahila mandal conveners' meetings, method demonstrations, plant/animal health camps, scientists' visit to farmers' fields, self-help group meetings, soil health camps, soil-test campaigns, workshop and others

SUCCESS STORY

Horticultural Crop Nursery Business for Self-employment in district Nimbudera, Andaman and Nicobar Islands

Shri Om Prakash, a young man, lives in Govindpur village near KVK office in Nimbudera of North and Middle Andaman. He studied up to 10th class. He is the only earning member of his five-member family. He has 0.5 ha of agricultural land. In 2018, Shri. Om Prakash approached KVK, Nimbudera for technical guidance for growing quality planting materials. Further, he attended the training at KVK for learning on scientific nursery management and different plant propagation methods in horticultural crops. Then, he constructed a low-cost shade net and polyhouse for nurseries (10 m × 8 m) in his farm and purchased various nursery tools and implements. He started plant nursery for the production and supply of ornamental plants for flowering and foliage, vegetable seedlings and superior variety of local fruits. He started nursery by doing grafting in local superior varieties of mangoes, citrus and guava fruits. He also established mother plants of guava, mangoes, sapota and flower plants in his farm. Now he has 10 varieties of local type superior mangoes, 4 varieties of citrus fruits and 3 varieties of sapota. Shri Om Prakash is not only practicing different propagation methods but also doing conservation and multiplication of many native flowers, local fruit crops, orchids, ferns and other local ornamental foliage and flowering plants. Besides, he procured some ornamental and good variety of rose plants and started production of flower and ornamental plants and other useful medicinal plants. In 2019, he purchased hybrid seeds of flowering plants (marigold-inca, petunia, vinca, china aster etc). He is now totally engaged in horticultural crop nursery business and regularly selling various horticultural crop seedlings, plants etc. He earns net profit of ₹ 3 lakh from sale of flowering plants. In 2020, he was able to earn an additional income of ₹ 3.5 lakh. The success of Shri Om Prakash has set an example before the rural youth in the nearby villages for nursery business as a good source of income.

to create awareness among farmers, extension personnel, other stakeholders and public about various technologies in agriculture and allied sectors. These programmes were attended by 236.36 lakh participants of which 233.87 lakh were farmers and 2.49 lakh were extension personnel.

Besides, a total of 2.26 lakh mass contact extension activities were conducted in the form of TV programmes, radio talks, CDs/DVDs and print media, viz. extension literature, newspaper coverage, popular articles, research articles, training manuals, technical bulletins, leaflets, folders and books/booklets. Large number of activities were covered through extension literature (1,17,577). A total of 26,493 news items were published in local and national dailies. Scientists of KVKs published 4,798 popular articles besides 3,292 radio talks and 2,515 TV talks.

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 15.59 lakh farmers in the country.

Seeds: During the year, 1.51 lakh q seeds of improved varieties and hybrids of cereals, oilseeds, pulses, commercial crops, vegetables, flowers, fruits, spices, fodder, forest species, medicinal plants and fibre crops, were produced, and provided to 4.87 lakh farmers.

Planting materials: Total of 490.97 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 6.15 lakh farmers.

Bio-products: Bio-products, namely, bio-agents (129.68 q), bio-pesticides (1,429.97 q), bio-fertilizers (27,823.26 q), and other bio products (24,125.09 q) including vermi compost, mineral mixture etc., were produced for the benefit of farmers. Thus, a total of 53,508.00 q bio-products were produced and supplied to 4.09 lakh farmers.

Livestock, poultry and fish fingerlings: A total of 15,086 animals of improved breeds of cow, sheep, goat, buffalo and breeding bull were produced and supplied to 48,474 farmers. Likewise, 582,864 strains/breeds/eggs of poultry birds (chickens, quails, ducks and turkey) were provided to 33,739 farmers. Improved breeds of pigs (1,586) were provided to 484 farmers. KVKs also enabled 103 farmers to establish small rabbit rearing units by providing 471 rabbits. A total of 302.20 lakh fish fingerlings were produced and supplied to 12,521 farmers.

Soil, water and plant analysis

Soil, water, plant and manure samples of farmers' fields were analysed at KVKs, and suitable advisories based on analysis were provided to them. During the reporting period, 2.85 lakh samples comprising 2.50 lakh soil samples, 0.06 lakh water samples, 0.27 lakh plant samples and 0.02 lakh manure samples were analysed by KVKs covering 3.33 lakh farmers belonging to 0.42 lakh villages across the country and the revenue generated was ₹ 187.51 lakh. Soil health cards (2.45 lakh) were also issued to the farmers by KVKs.

SUCCESS STORY

Dragon Fruit Farming—An Innovative Business in Bastar district, Chhattisgarh

Mr Rohit Chavda, a farmer belonging to Pandanar village in Bakwand block of Bastar district has started dragon fruit cultivation as an innovative agribusiness in the year 2018 along with his father Mr Bharat Chavda on a commercial scale under the technical guidance of the Krishi Vigyan Kendra, Bastar. The farmer has started cultivating it in his 7 acres of land, in which the profit starts to accrue from the second working year of the crop on the basis of cost. Presently, the value of its fruit is ranging from ₹ 120 to 150/kg, resulting in a gross income of ₹ 1,125,000/ha. The farmer may receive higher income in years to come.

Technology backstopping to KVKs

A total of 52 Directorates of Extension Education (DEEs) of the SAUs/CAUs have played a crucial role in technological backstopping to KVKs of India. During the reporting period, the DEEs organized 562 capacity development programmes for updating the technical knowhow of 17,845 KVK staff in the country. The DEEs facilitated technological backstopping for KVKs by conducting 1,478 training programmes, 537 field days, 8,987 farmer scientist interactions, 830 soil health camps, 307 Kisan melas, 1,723 kisan goshties and 150 technology week celebrations. Further, monitoring of KVK interventions (8,804), *rabi* and *kharif* campaigns (228), animal health camps (947), diagnostic visits (6,206) and technology exhibitions (331) were also taken care by the DEEs during the period under consideration. The officers of DEEs also delivered 680 lectures, 240 TV talks, 974 radio talks and 11,064 news reports in newspapers for ensuring technology backstopping for the KVKs. A total of 36,603 farmers visited Directorate of SAUs/ CAUs for getting improved technology knowledge during the period under consideration.

Agricultural Technology Information Centre

A total of 47 Agricultural Technology Information Centres (ATICs) are functioning as single window delivery system in the country and are serving very important purpose by providing technology information, advisory services and technological inputs to the farmers. Under the period of reporting, 2.86 lakh farmers visited ATICs for obtaining solutions related to their agricultural

ARYA Entrepreneur Support Centre at KVK Pathanamthitta to facilitate marketing (*left*); Exhibition of products of ARYA entrepreneurs (KVK Pathanamthitta, Kerala) (*right*)

problems and purchasing key farm inputs. Further, ATICs provided information on various aspects of farming to 2.88 lakh farmers through various modes such as personal communications and print and electronic media during this period. A total of 1.47 lakh farmers were provided 3.7 lakh q disease free seed of various crops along with 56.6 lakh improved planting material, 30,415 poultry birds and 877 q bio-products by all these ATICs. In addition, 13.11 lakh farmers benefited from technological services provided by various ATICs. ATICS also provided various services, viz. Soil Health Cards (15,346 farmers), Kisan Call Centre (1,12,626 farmers' calls), Postal services to farmers (978), Mobile Agro Advisory (8.03 lakh) and special extension programmes (690).

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 reporting period, 3,387 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 were established benefiting 5,394 rural youth. These KVKs organized 775 training programmes benefiting 16,812 youth. Nearly 20% trained rural youth established micro-entrepreneurial units in rural areas which benefited them to get net income ranging from ₹ 33,088 to ₹ 630,000/unit/annum across the different entrepreneurial units.

National Innovations in Climate Resilient Agriculture: Technology Demonstration Component (TDC) of National Innovations in Climate Resilient Agriculture (NICRA) is being implemented through KVKs in 121 climate vulnerable districts of the country wherein climate smart technologies under National Resource Management, Crops and Livestock modules have been demonstrated along with institutional interventions. Capacity building and extension activities are also a part of TDC NICRA to bring larger awareness on climate resilient technologies and to instil climate literacy among farmers. During the year under report, 20,185, 26,571, 15,658 demonstrations were conducted covering 21,958.79, 11,554.39 and 581.28 ha of area under NRM, crop and livestock modules, respectively. At the same time 1,651 capacity building programmes and 4,640 extension activities were taken up for the benefit of 41,568 and 70,828 farmers, respectively, for brining awareness on climate resilient technologies and to enhance climate literacy.

Skill development training in agriculture: Skill development in agriculture sector is one of the priority areas of Government of India. With funding support from Department of Agriculture and Farmers' Welfare, KVKs/ ICAR Institutes/Agricultural Universities organized 120 National Skills Qualifications Framework (NSQF) aligned skills training programmes of 200 hr or more duration benefitting 2,915 rural youth during the period under report. The highest number of trainings programmes were organized in the job role of Mushroom Grower (21) followed by Dairy Farmer (15), Quality Seed Grower (11), Nursery Worker (9), Small Poultry Farmer (8), Organic Grower and Vermicompost Producer (7).

Farmer FIRST: Farmer FIRST Programme is an initiative 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. Under this programme, a total of 24,826 demonstrations were conducted, 2,299 extension programmes were organized, 59,037 animals (livestock and poultry) were benefited and 108,113 farm families were covered in all modules.

Out of the total demonstrations conducted, highest number of demonstrations (8,869) were conducted in crop module followed by 6,270 demonstrations in livestock and poultry; 5,946 demonstrations in horticulture module; 3,572 demonstrations in NRM module and 169 demonstrations in IFS module.

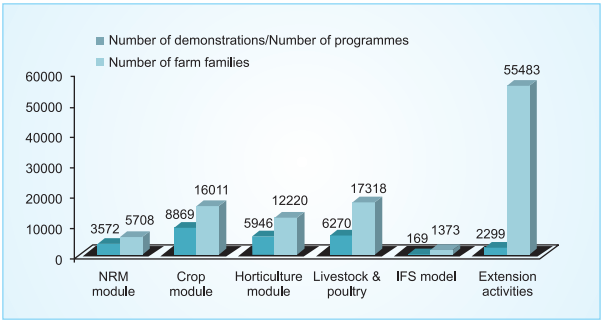
Out of the total farm families covered under this programme, 16,011 farm families were benefitted in crop module; 5,708 farm families in NRM module; 12,220 farm families in horticulture module; 17,318 farm families in livestock and poultry module; 1,373 farm

Direct Seeding of Rice with drum seeder (KVK, Chittoor, Andhra Pradesh)

Check dam filled with rainwater – KVK, Chikkaballapur, Karnataka

Animal health camp – KVK, Jodhpur, Rajasthan

families in IFS module and 55,483 farm families in extension activities.



Module-wise no. of demonstrations/programmes

Integrated Farming System

Hatching of Kadaknath Eggs

Mera Gaon Mera Gaurav: The innovative initiative *Mera Gaon Mera Gaurav* (MGMG) aims at promoting the direct interface of scientists with the farmers to hasten the lab to land process. The objective of this scheme is to provide farmers, particularly small and marginal ones, with required information, knowledge and advisories on regular basis by adopting villages. During interaction with scientists, farmers put forth their issues like, apropos technological availability, loans, market price, extension programmes and support provided by different agencies, etc.

MGMG has been implemented by 121 institutions (ICAR institutes and SAUs) during the period under report). A total of 1,154 groups involving 4,417 scientists covered 4,055 villages, conducted 41,402 field activities including awareness, demonstrations, training, meetings, etc. by which 66,2916 farmers have been benefited.

Pulses seed-hubs: Seed-hubs have been set-up at 95 KVKs for production of quality seeds of major pulse crops. During the year, 34,728.25 q seeds of pigeon pea, blackgram, greengram, lentil, chickpea, field pea and lathayrus were produced and made available to farmers.

Crop residue management: The states of Punjab, Haryana and western Uttar Pradesh, also known as the birthplace of Indian Green Revolution, are the major

SUCCESS STORY

Duck farming provided lucrative income to Shri Baijnath Mahto during COVID-19

Farmers of Ramgarh district, Jharkhand, were mainly growing the cereal crops and vegetables. The farmer Sri Baijnath Mahto, resident of village Takha, block, Mandu, Ramgarh has started duckery unit under the technical guidance of KVK, Ramgarh. Training and exposure was provided by KVK in the January 2020. He started with 500 birds of Khaki Campbell ducklings, which started egg production from April 2020 in a range of about 80–100 eggs/day. Further, he integrated duck farming with fisheries and vegetable cultivation for higher return. For vaccination and diagnostic services, he linked with animal husbandry department, Jharkhand. During COVID-19 period, he lost farm income but he received ₹ 72,000 income through selling of eggs during the year which was helpful for his family livelihood.

SUCCESS STORY

Intercropping of ber in date palm: a way forward for doubling of farmers' income

Shri Sona Ram belonging to Bhedana village Gudamalanito tehsil of Barmer district planted Date palm (variety Barhee) in 2016. He planted 208 date palms at row to row spacing of 8 m and plant to plant spacing of 6 m in one ha area. He obtained low benefit cost ratio due to high cost of cultivation that compelled him to think of some innovation. Then he took initiative of intercropping ber in date palm fields under the supervision of KVK, Barmer-II. He has planted 204 ber plants as intercroping in date palm fields. The flowering and harvesting of date palm is February to March and July to August, whereas ber plants are August to September and December to February, respectively, in arid region. The planting of additional ber plants provides an additional income. Intercropping of ber has helped farmer to take higher profit than sole cropping of date palm. He obtained net returns of ₹ 206,855/ha and B: C ratio of 2.12 by cultivation of date palm. With intercropping of ber net return is being realized to the tune of ₹ 278,095/ha.

Seed distribution

Training programme on Integrated Farming System (IFS)

contributors to the national food basket for paddy and wheat. Most of the farmers of these states generally resort to burn paddy straw in the field itself due to short window (10–20 days) for timely planting of ensuing crops. The enormous burning, that too within a span of 15 days, leads to atmospheric pollution problems, massive nutritional losses and deterioration of physical and biological health of the soil. Keeping this in view, 60 KVKs of these states and Delhi (22 KVKs of Punjab, 15 KVKs of Haryana and Delhi and 23 KVKs of UP) are implementing Information, Education and Communication (IEC) component of the Scheme on Promotion of agricultural mechanization for *in situ* management of crop residue to educate the farmers and other stakeholders about ill effects of crop residue burning since 2018.

A total of 95 machines were procured by the KVKs in this period out of which Rotavator assumed the lead role followed by Mulcher/Paddy Straw Chopper and Happy Seeder, etc. Under this component 54 Kisan melas were organized in which 34,898 participants were educated on the significance and urgency of CRM; 1,139 awareness programs targeting 89,731 participants; 494 schools and colleges mobilizing 32,293 students through essay, debate and painting competitions; 16,272 demonstrations focusing on 19,757 farmers; 354 training programs benefiting 12,319 participants; 164 exposure visits of 5,230 participants and 331 field/harvest days were organized to demonstrate results to 10,865 persons.

Other activities under IEC initiative of CRM project include distribution of 4.96 lakh publicity material (leaflets/ pamphlets etc.); placing 9,159 posters/ banners; 8,669 wall paintings; fixing of 4,009 hoardings at mandi/ road side/market/schools/petrol pumps/panchayats etc.; publication of 674 articles and news-items in the newspapers and magazines; 875 advertisements in the print media; and 70 TV programmes/ panel discussions on Doordarshan/ DD-Kisan and other private channels.

Out of total demonstrations, 12,408 demonstrations were conducted on nutritional garden involving 17,497 participants, 233 on nutri-rich biofortified varieties of crops (4,342 participants) and 352 demonstrations on value-addition of different crops, viz cereal, millets, vegetables and fruits with 6,636 participants.

Knowledge system and homestead agriculture management in tribal areas: The programme of Knowledge Systems and Homestead Agriculture Management in Tribal Areas (KSHAMTA) is being implemented by channelizing the Tribal Sub Plan fund of ICAR institutes for Development of Tribal Agriculture in 125 tribal districts of the country through KVKs. Capacity development of 1.93 lakh farmers/farm women/ rural youth and 17 thousand extension personnel were done under the programme. The KVKs conducted 4,371 on-farm trials and 28,344 frontline demonstrations. The technological inputs like seeds (18,239.20 q), planting material (83.82 lakh) and livestock strains and fish fingerlings (30.25 lakh) were produced and made available to the farmers of the area. Besides, KVKs also analysed 52,154 samples of soil, water, plant and manure and provided Soil Health Cards (66,874) to the farmers. These KVKs also organized large number of extension activities benefitting 19.97 lakh farmers.

Demonstration on Nutritional Garden under NARI

SUCCESS STORY

Innovative micro-integrated farming system model

IFS is an interdependent, interrelated often interlocking production systems based on few crops, animals and related subsidiary enterprises in such a way which maximizes the utilization of resources of each system and minimizes the negative effect of enterprises on environment. The land terrain of Meghalaya hilly regions does not give advantage to the farmers to conquer the idea in large scale. Mrs Valarie Maring belonging to NICRA village Kyrdem of KVK Ri-Bhoi has developed a Micro-Integrated Farming System model by utilizing her *jalkund*, poultry unit and high-tech polyhouse to an economically viable innovative model. She established a *jalkund* unit of size 5×4×2 cu. ft. with a capacity of 40,000 litres of water by lining the *jalkund* with HDPE for effective storage of rainwater during *kharif* followed by release of fish fingerlings of Indian major carps into the *jalkund* unit, construction of poultry shed with 40 numbers of dual-purpose *Vanaraja* breed of poultry which act as a source of nutrients and biomass for fish and establishment of a high tech polyhouse in convergence with District Horticulture Office, Nongpoh for growing of cut flowers gerbera which has an advantageous output in the tribal areas of Ri-Bhoi district. From this micro-integrated farming system model, she could earn a net income of ₹ 89,410/year of which Rs 20,400 from poultry meat, ₹ 22,300 from poultry eggs, ₹ 4,870 from fish, and ₹ 41,840 from Gerbera. The activities are complimenting in this micro-integrated farming system, mitigating negative environmental effect through proper recycling of nutrients and resources.

Nutri-sensitive Agricultural Resources and Innovation: Nutri-sensitive Agricultural Resources and Innovations (NARI) is a flagship programme of ICAR for improving health and nutrition of rural women. Under this programme, total of 12,993 demonstrations on nutritional garden, biofortified varieties of crops and value-addition were organized in addition to 2,883 training programmes (74,368 participants) and 5,108 extension activities (7,43,186 participants).

Initiatives 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 post-harvest activities. An added impetus was given to the attempts made during the previous year with reference to brining 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 *kharif* 2021 and *rabi* and summer 21–22 in 15 different local languages were compiled, uploaded on ICAR website and disseminated by KVKs through extensive use of ICT platforms and social media.

A total of 430 awareness programmes were conducted by KVKs across the country to bring awareness on covid appropriate behaviour among 79,470 farmers during the period under report—crop (8,486) and livestock (3,320) related advisory were given by KVKs during the crop seasons for the benefit of 1,504, 400 and 196,264 farmers respectively. A total of 560 different interventions were undertaken by KVKs with respect to facilitating marketing of farm produce amidst constraints posed for transport of commodities during second wave of COVID 19 benefitting 108,815 farmers. In addition to these attempts, 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 50,000 farmers.

Awareness program on COVID 19 and distribution of kitchen garden kits to Anganwadi workers – KVK, Tinsukia

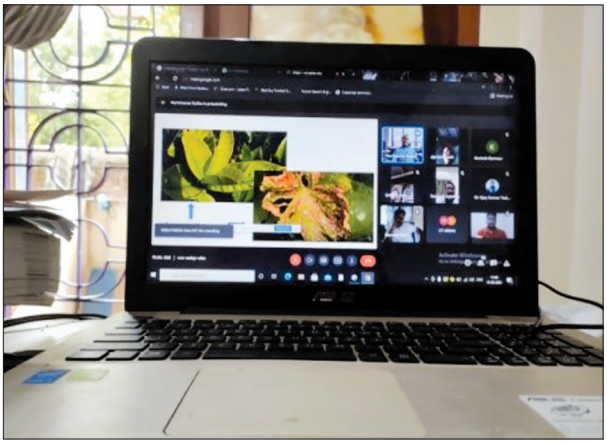
SUCCESS STORY

Diversifying crop sequence for higher returns in Khamman district of Telangana

Mrs Ch. Ramulamma, a woman farmer from Khammam district of Telangana has been cultivating rice for many years and was not able to gain sufficient income for livelihood. Under the technical guidance of KVK, Khammam (Wyra), she adopted crop sequence and latest production technologies. She followed direct sowing in rice that helped her to overcome the labour shortage and also to get the produce 10 days earlier compared to traditional practice. This further helped her

to sow maize crop at correct time by practicing zero tillage in maize. From 3 acres of land, she obtained 3,000 kg of paddy per acre and earned gross returns of ₹ 1.63 lakh with a net profit of ₹ 28,450 and B:C ratio of 2.10:1 during *kharif* 2019–20. She realized highest yield of about 45 q/acre of maize and got gross returns of ₹ 88,000 with a net profit of ₹ 64,500/acre and from overall two acres, she realized gross returns of ₹ 1.76 lakh. In the remaining one acre of land, she had grown sesame crop and achieved an yield of 3 q and earned a net profit of ₹ 16,000. Thus, she used land effectively by cultivating three crops and innovatively adopting the cost reducing technologies like direct seeding and zero tillage for paddy and maize, thus setting an example to fellow farmers in adoption of labour reducing and cost reducing technologies. Mrs Ramulamma received appreciation certificate from Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad on 5th University Foundation Day.

Promotion of Farmer Producer Organizations: Indian Council of Agricultural Research signed an MoU with National Cooperative Development Corporation, Government of India, New Delhi for formation and promotion of farmer producer organizations (FPOs). KVKs (56) and ICAR institutes (5) are working as cluster based business organizations for formation of 117 FPOs in 117 blocks of 55 districts in 25 states/ Union Territories of the country. Besides, KVKs are also providing handholding support to the FPOs established by other organizations all over the country.



Virtual training on nutrient management – KVK, Goalpara

Maintaining social distancing during field operations –KVK, Lungle

❑

15. Research for Tribal and Hill Regions

NORTH WEST HIMALAYAS

Breeder seed production: During the period, 187 q breeder seed of 47 released varieties/inbreds of 17 crops were produced. A total of 148.36 q breeder seed was supplied to different seed producing agencies to take up further multiplication.

Quality seed production: During the period, 9.93 q truthfully labelled (TL) seed of 20 varieties of 13 crops was produced. Including the carry-over stock of TL seed; a total of around 15.4725 q TL seed was supplied to different stakeholders.

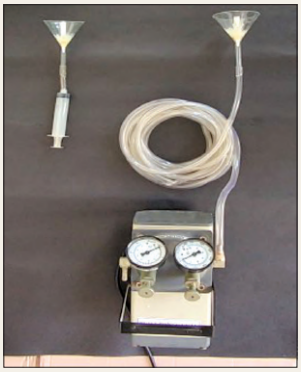
Crop Production

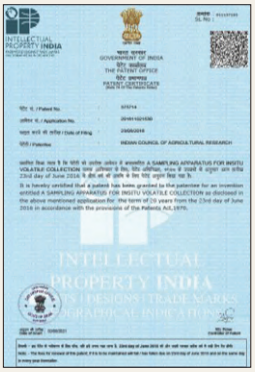
Water budgeting for growing vegetables crops in terraced land: A study was conducted to derive operational model for a farm tank of 46 cubic meter capacity at Experimental Research farm of ICAR-VPKAS, Almora. The tank capacity is efficiently designed to irrigate 0.34 ha area in terms of *kharif* + *rabi* + *zaid* for growing vegetables in terraced land. The estimated water requirement of studied crops (tomato, capsicum, okra, french bean, chilli, vegetable pea, cabbage, broccoli and kidney bean) in 0.34 ha area under micro and surface irrigation 749.61 m^3 and 1,274.15 m^3, respectively. The water saving of 41.16% was estimated in micro irrigation as compared to surface irrigation. The simulation study revealed that increased command area or auxiliary water harvesting structure required at experimental site for storing maximum runoff water 230.82 m^3, 181.36 m^3, and 157.7 m^3 in July, August, and September, respectively. The required design of tank capacity was 250 m^3 at experimental site for irrigating 0.11 ha area additionally in terms of studied crops grown during *kharif* + *rabi* + *zaid* under micro irrigation system.

Water budgeting for growing vegetables

An apparatus for *in situ* collection of insect pheromones

A sampling apparatus for *in situ* volatile collection invented by ICAR-VPKAS, Almora was been granted patent (Patent No. 373714). The apparatus was successfully utilized to collect the pheromone of scarab

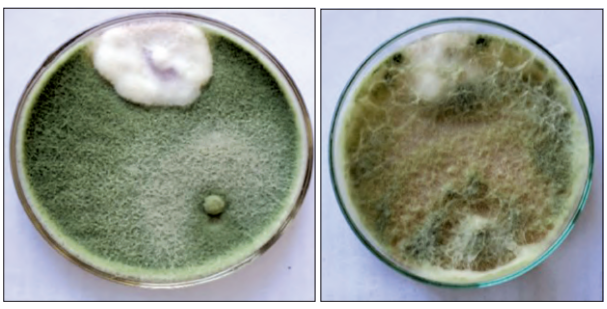




beetle/chafer beetle/white-grub beetle, *Holotrichia seticollis* (*Coleoptera*: *Scarabaeidae*: *Melolonthinae*). *Holotrichia seticollis* is one of the predominant white-grub species in Uttarakhand (Almora) but do not get attracted to light. This less-phototactic nature of *H. seticollis* makes light trap not effective for its management. However, the pheromone extracted from *H. seticollis* using the above apparatus was effective in trapping *H. seticollis* males in the field aid in pest management.

Crop Protection

***In vitro* evaluation of *Trichoderma* isolate Tr-202 against *Fusarium oxysporum* f. sp. *lentis*:** The antagonistic potential of *Trichoderma* isolate Tr-202 were assessed against *Fusarium oxysporum* f. sp. *lentis* through dual culture technique. *Trichoderma* isolate Tr-202 showed significantly higher inhibition (72.2%) as compared to commercialized *Trichoderma* isolate Tr-28 (65.5%).The 550 bp ITS gene fragment of both the *Trichoderma* isolates (Tr-28 and Tr-202) were sequenced and the sequence were deposited in NCBI GenBank. A phylogenetic analysis-based on the ITS region was performed, the maximum parsimony analysis of ITS gene confirmed, both the isolates as *T. harzianum*.



Fusarium oxysporum—TR 28 (*left*), TR 202 (*right*)

Crop varieties released and notified

Variety	Area of adoption	Salient features
Biofortified		
VL QPM Hybrid 59 (FQH 106)	Uttarakhand hills Organic	• Early maturing (85–90 days in mid-hills); high yielding (3,327 kg/ha) single-cross quality protein maize (QPM) hybrid • Possess mean tryptophan content of 0.77% and lysine and protein content of 3.33 and 8.91%, respectively • Yellow, semi-flint and medium bold grains (avg. 1,000–grain wt. 325 g) • Moderate resistance against *turcicum* and *maydis* leaf blight
Nutri cereals		
VL Chua 110 (Grain amaranth)	Uttarakhand hills Organic	• Average grain yield, 1,390 kg/ha; maturity in 115 days; High protein content, 14.2%; high lysine content, 6.3% and high calcium content, 221.3 mg/100 g in grains
VL Mandua 378	Uttarakhand hills Organic	• Average grain, 2,296 kg/ha; maturity, 110–114 days • High calcium content, 361.3 mg/100 g in grains
VL Safed Mandua 382 (Finger millet)	Uttarakhand hills Organic	• First white grain finger millet variety of Uttarakhand • Yield, 1,198 kg/ha
Wheat		
VL Gehun 2015	Uttarakhand hillsOrganic	• High yield + 19–88 q/ha • High resistant to yellow and brown rust • good chapatti making quality with good flour recovery
Rice		
VL Dhan 88	Himanchal Pradesh, Meghalaya and Uttarakhand	• Early maturing variety, 115 to 120 days under irrigated transplanted ecosystem • Grain yield in 4,963 kg/ha in lower hills and 4,332 kg/ha in medium hill region • Long bold grain with plant height of 123–130 cm under lower hill and 111–126 cm under medium hill region • Moderate resistance against leaf blast, neck blast, sheath blight and bacterial leaf blight
VL Dhan 159 (VL 20083)	Uttarakhand hills Organic	• Early maturing, 100–115 days; yield, 1,964 kg/ha under organic conditions • Long bold grain, plant height 95–100 cm • Resistance against leaf and neck blast, brown leaf spot, sheath rot, false smut, leaf scald, stem borer and leaf

VL Chua 110

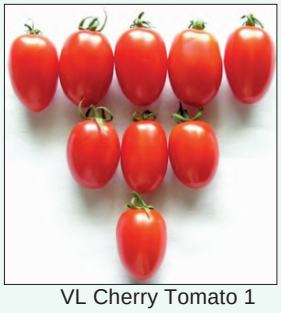
VL Mandua 378

VL Safed Mandua 382

VL Gehun 2015

VL Dhan 88

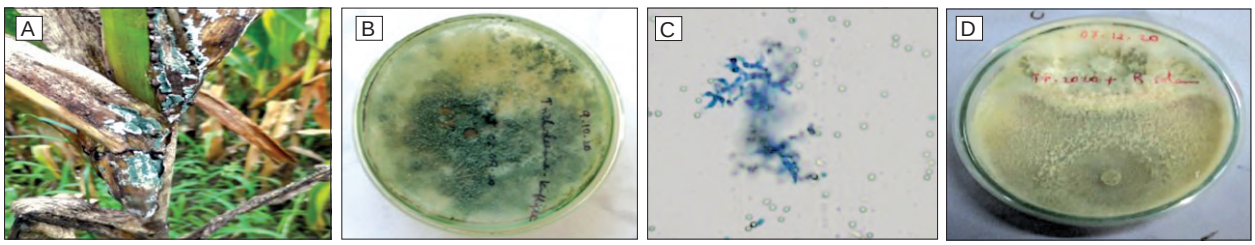
VL Dhan 159

Variety	Area of adoption	Salient features
VL Sikkim Dhan 4	Sikkim  VL Sikkim Dhan 4	• Unique decorticated grain colour (reddish brown) • Yield, 4,855 kg/ha • Medium maturity duration, 135 days; high number of panicles/m^2 (344) • Resistant to leaf blast; sheath rot, brown spot, sheath blight, false smut diseases; prevalent pests leaf folder, stem borer, green hopper and gundhi bug under natural condition
Vegetable		
VL *Sabji Matar* 14	Uttarakhand	• High yielding variety; average green pod yield, 125 q/ha • Resistance against powdery mildew disease  VL *Sabji Matar* 14
VL Cherry Tomato 1	Uttarakhand, HP, Union Territory of J&K, Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunachal Pradesh, Union Territory of Andaman and Nicobar, Madhya Pradesh, Maharashtra and Goa	• First cherry tomato variety of the country • Average yield, 250–300 q/ha under open-field conditions, 400–500 q/ha under polyhouse conditions • Fruits are small, attractive red colour with oval shape; better in nutritive traits (vitamin C- 86 mg/100 g and TSS –7° Brix)  VL Cherry Tomato 1

A new isolate of *Trichoderma* sp.: promising against *Rhizoctonia solani* of maize: A survey was conducted during *kharif* 2020 to Almora and Bageshwar districts, Uttarakhand. During survey, a bio-control parasitizing *Rhizoctonia solani* of maize causing banded leaf and sheath blight disease under field conditions was observed and collected from Krishi Vigyan Kendra, Kafligair, Bageshwar, Uttarakhand (29.75°N 79.74°E, 1,275 m amsl). Under microscopic observations, conidiophore bearing conidia were observed. Conidiophores were repeatedly branched, irregularly verticillate, bearing clusters of divergent, often irregularly bent, flask-shaped phialides. Conidia were hyaline to pale green in colour, with smooth walls and formed in slimy conidial heads clustered at the tips of the phialides. The fungus was promising in inhibiting the growth of test pathogen.

Mechanization

Light weight maize sheller for hills: In North Western Indian Himalayan Part of India, maize shelling and harvesting operation is performed manually. Most common manual operated maize sheller is octagonal hand maize sheller. But, the capacity of this sheller is up to 15–20 kg/h which is time consuming and tedious activity. Power operated VL maize sheller (single phage, half hp electrical motor) gave satisfactory performance during testing. The average shelling capacity and efficiency was 305 kg/h (15 time higher than the octagonal hand maize sheller) and 93% respectively at 14% moisture content and 10 degree working slope. The machine is under the process of commercialization. This sheller machine does not break the cob wood and farmers may use this whole cob as wood for fuel in their domestic use. One person can perform the whole operation.



(A) Bio-control agent parasitizing maize plant; (B) Pure culture of *Trichoderma* spp.; (C) Spores of *Trichoderma* spp.; (D) Bioassay of *Trichoderma* spp. against *Rhizoctonia solani*

VL maize sheller

Post-harvest management and value-addition

Light weight multi-fruit-cum-vegetable grader: The multi fruit grader was developed using combination of three different rollers to provide three grades. Length of rollers was 480, 350 and 295 mm bigger diameter roller was used for providing smaller gaps. Fruits were allowed to pass through bigger roller to smaller one so that smaller fruits will pass through first and bigger fruits would pass at last. These rollers were arranged concentrically on single shaft (20 mm). Two sets of roller were used in one machine. At the centre, and in between two rollers an idle roller of 64 mm diameter and 1,125 mm length was used for guiding fruits between two rollers. The multi-fruit grader was tested for different fruit and vegetable and its capacity was 605 kg/h. Fruit grader operated by solar and manual energy.

VL multi-fruit-cum-vegetable grader

Nutri-smart village: Nutrition sensitive approach was promoted at local level with active participation of women who are mainly responsible for food security of the households in high hill areas. Initial survey showed overall prevalence of malnutrition among women depicted as different grades of CED along with low normal BMI was 36.5%. Women had very low dietary diversity score (3.9) as 69.8% women were found consuming less than five food group in their daily diet. As an intervention under NMHS funded project, 63 nutri-gardens with well-established layout were demonstrated in high hills of Pithoragarh and Uttarkashi district to increase the local availability of

Nutri-smart village

nutritionally rich food. In order to address the issue of low productivity, high yielding varieties of wheat, finger millet and lentil (major crops of hill region) were introduced in the project area along with the recommended package of practices. Diverse food availability was ensured through family farming, nutri-gardens and homestead production of vegetables, fruits, mushroom, honey, micro-greens, fortified crop varieties etc. at local levels. After the implementation of nutrition sensitive agricultural intervention, dietary diversity score reached to more than 5. As a result of these interventions, there was significant improvement in consumption of food groups like pulses, other vegetables, mushroom, fruits and milk in diet of beneficiaries. Women were organized in Himalayan Self Help Group, Jogat in Uttarkashi district; Poshan Suraksha Self Help Group, Baitholi; and Poshan Vatika Self Help Group, Kande-Kiroli in Pithoragarh district. These groups were formed to enhance feasibility and effectiveness of nutrition focused interventions. This model of nutri-smart village proved that a small nutri-garden of 100 m^2 to 200 m^2 along with location specific nutrition sensitive agriculture interventions can provide round the year food and nutritional security for a family of 5–6 members in hills.

NORTH EAST HIMALAYAS

Integrated organic farming system (IOFS) model for sustainable livelihood: An integrated organic farming system (IOFS) model (0.43 ha area) developed at ICAR Research Complex for NEH Region, Umiam,

SUCCESS STORY

Farmer Participatory Seed Production of Garden pea at Bail-Parao, Nainital, Uttarakhand

The availability of quality seed of recommended improved vegetable varieties is inadequate in the state. Feasibility and acceptability for large scale seed production at farmer field of newly released varieties are to be tested.

In order to tackle the mentioned challenges/issue the varietal demonstration-cum-seed production of newly released varieties of garden pea, viz. VL Sabji Matar 13 (early maturing variety) and VL Sabji Matar 15 (medium maturing variety with field resistance to powdery mildew) was carried out during *rabi* 2019–20 by the Institute in Narrottampur (Bail-Parao, Nainital, Uttarakhand) on 2 acres area (29.3089°N, 79.2014°E) of farmer Mr Rahul Singh who showed his willingness to take up these varieties. The demonstration-cum-seed production plots of VL Sabji Matar 13 and VL Sabji Matar 15 were frequently monitored by institute scientists for providing timely technical know-how and for ensuring varietal genetic purity. A field day was organized at Narrottampur village on, which was attended by around 50 farmers from Bailparao.

This approach was found very much useful in the dissemination of new varieties among farmers and more farmers can be trained in seed production at massive scale. In coming *rabi* seed production of these varieties will be planned to take in 5 ha land in same and nearby villages. This strategy will not only provide the quality seed in a large quantity but also strengthen the process of bringing farmers under seed production program with better income option, and that may be treated as an effective capacity-building strategy concerning vegetable seed Industries.

After notification, in the very first year of both these varieties, 6.155 q seed was harvested and supplied by the farmer to the Institute. The variety-wise details of seed received are below mentioned:

TL Seed procured from Mr Rahul Singh during 2019–20

Garden pea variety	Seed received (q)
VL Sabji Matar 13	4.695
VL Sabji Matar 15	1.460

Mr Rahul Singh, the farmer who is directly associated with the seed production of both varieties, expressed his satisfaction over the performance of these varieties. The income gained by seed-producing and by direct procurement of seed by the Institute (at Institute approved rate ₹ 120/kg of quality seed) to the farmer is 0.74 lakh rupees. He shared his experience with fellow farmers and farmers from his village showed their willingness to take-up these varieties for cultivation as well as seed production in coming *rabi* season.

Deliberation by The Director, ICAR-VPKAS, Almora during the field day

Imparting technical know-how of varieties

Visit to the seed production field

Rouging in the seed production field

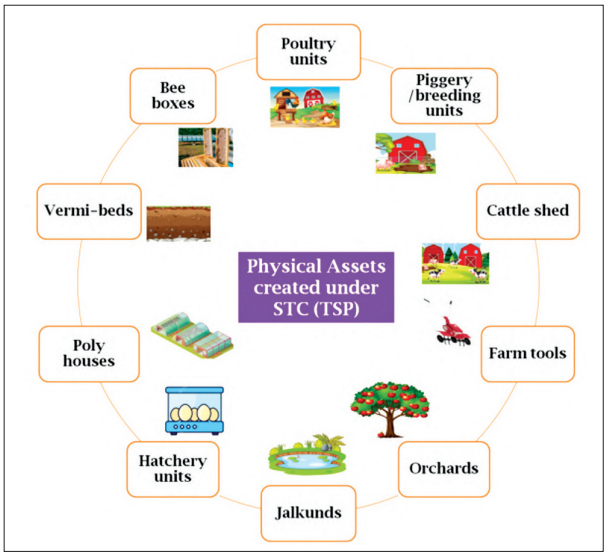
Meghalaya to meet the diverse requirement of the farm household while preserving the resource base and maintaining the environment. The model has diversified farming components like field crops (cereals, pulses, oilseeds), horticultural crops (vegetables, fruits), livestock (one cow + calf), duckery (20 ducks) along with perennial fodder crops, composting units and central water harvesting pond for composite fish culture and as a source for irrigation during lean season. The IOFS model on 0.43 ha area generate on an average net return of ₹ 82,450/ year (₹ 191,744/ha/year) with a B : C ratio of 2.43 which is much higher than that of the region's

IOFS model at ICAR Research Complex for NEH Region, Umiam

Vertical cropping over Jalkund in IOFS model

farmer common farming practices. On farm nutrient recycling in the IFOS model also supplied approx. 95.8% of the total N requirement, 84% of the total P_2O_5 requirement and 100% K_2O requirement thus making the model near sustainable. The IOFS models were also disseminated to farmers' field in cluster approach in 3 villages of Ri-bhoi district of Meghalaya covering about 110 ha area and 317 households.

Livelihood development under scheduled tribe component (STC; erstwhile TSP): More than 6,503 tribal farmers from the North Eastern states, i.e. Manipur (544), Megahalaya (708 Nos), Mizoram (502 Nos), Nagaland (232 Nos), Sikkim (2300 Nos.) and Tripura (2,217 Nos) benefitted during reporting period through various livelihood programmes under Tribal Sub-Plan (TSP). A total of 121 numbers of different physical assets, viz. small scale poultry unit (10 Nos), Small scale piggery unit (20 Nos), Poultry house construction under IFS (4 Nos), Cattle shed Construction under IFS (4 Nos), Farm machineries (24 Nos), Bee box (80 Nos), Orchard (Mango, Litchi and Assam Lemon) of 3 Nos, Jalkund (4 Nos), Hatchery unit with accessories (2 Nos), Low cost poly house (4 Nos), Vermi bed (4 Nos), pig breeding unit (2 Nos) were created/distributed in different tribal villages of north east India. Further, 29,600 man-days (267 no. of households) of employment was generated for livelihood security of tribal farmers during the reported period.



Physical assets created under STC (TSP)

Prominent varieties released: During the reporting year a number of crop varieties developed by the institute were notified by CVRC including several varieties of rice (Tripura Khara 1, Tripura Khara 2, NICRA Aerobic Dhan 1, TRC 2014-8, Gomati Dhan, TRC 2005-1, Tripura Nirog, Tripura Chikan Dhan, Khowai, Tripura Sarat, Tripura Jala, Tripura Aus, Tripura Hakuchuk-1); three varieties of pulses (TRCP 9- Field Pea, Tripura Mung 1- Greengram, Tripura Maskolai-Blackgram), two varieties of oilseeds (Tripura Siping-Sesame, Tripura Toria), and two varieties of brinjals

Tripura Khara 2

Tripura Maskolai - Blackgram

(TRC Singhnath, TRC Bholanath).

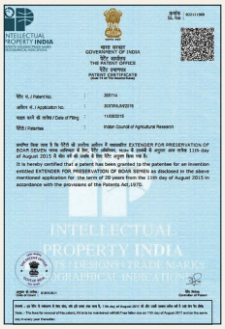
Diagnostics for plant and animal health: Rapid diagnostic kits for plant and animal health were developed at the institute. For plant diseases 4 kits were developed including Double Antibody Sandwich-ELISA kits for Passion fruit Potyvirus, RPA-LF Kit for on-site Detection of *Candidatus liberibacter asiaticus* (Citrus Huanglongbing Disease), isothermal RPA detection kits for pathogens of citrus, passion fruit and chilli. On the animal health side equipment free point-of-care diagnostics based on polymerase spiral reaction and SRCA were developed for *Staphylococcus* spp., Salmonella spp., *Campylobacter jejuni*, *C. coli* and *Clostridium perfringens*.

ISLAND AND COASTAL REGION

Vision document to make Goa self-reliant in agriculture released: A vision document, 'Vision for Development of Agricultural and Allied Sectors: A Way Towards Making Goa Self Reliant (Swayampurna Goa)', was released during the 26th Meeting of ICAR Regional Committee No. VII.

Patent granted to "Extender for the preservation of boar semen"

An application No. 3037/MUM/2015 dated 11 August 2015, entitled "Extender for the preservation of boar semen" invented by ICAR-CCARI, Goa, was granted patent No. 355114 on 1 January 2021.



The boar semen invention helps in effectively preserving porcine semen of pig for periods extending at least 48 to 72 h ideally and even up to 120 h or more, at holding

temperatures of 15–17°C. This extender preserves pig semen in a liquid state. This extender has a simple, cost-effective protocol and is easy for even a layperson to use. Researchers have used this product for their research work, and different pig production centres in neighbouring states regularly procure this extender for pig breeding through AI. Potential beneficiaries of this technology include pig farmers, researchers, state animal husbandry departments, industrialists and agri-entrepreneurs.

Commercialization of technology- Process for manufacturing of Nutmeg Pericarp Taffy: A Memorandum of Agreement (MoA) was signed between ICAR-Central Coastal Agricultural Research Institute (ICAR-CCARI), Goa and Goa State Biodiversity Board (GSBB), Goa, for commercialization of ICAR-CCARI's technology "Process for manufacturing of Nutmeg Pericarp Taffy" at ICAR-CCARI, Old Goa on 19 February 2021. The non-exclusive licensing agreement is valid for five years with a licence fee of ₹ 354,000, fully paid by GSSB, Goa. The technology helps in effective utilization of pericarp, otherwise discarded, by preparing the Nutmeg Taffy, a value-added food product, in a commercially feasible manner. The product stores well at room temperature for about 12 months with simple packing without any synthetic preservatives.

Two new brinjal varieties resistant to bacterial wilt released: Two wilt resistant varieties, viz. Goa Brinjal 5 and Goa Brinjal 6 has been developed for cultivation in Goa. Both the types are oblong, purple with a yield of 230–250 q/ha and resistant to bacterial wilt.

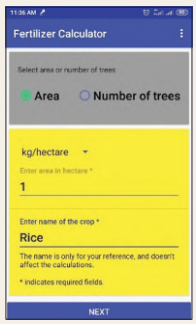
Goa Brinjal-5

Goa Brinjal-6

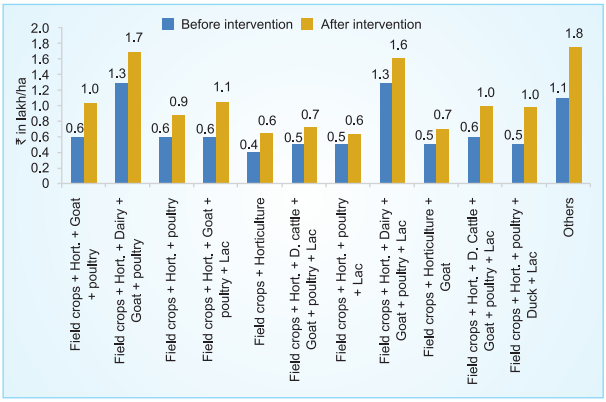
Integrated Farming System Models for eastern plateau and hill region: Integrated farming systems were introduced for monocrop prevailing in Eastern Plateau and Hill region through participatory approach. The activities were undertaken in three villages situated at a distance 18 to 21 km from Ranchi, Jharkhand. Among the different systems, field crops + Horticulture + Dairy + Goatary + Backyard poultry was found to be the most prominent farming system with total agricultural income per ha of land holding of ₹ 1.3

Fertilizer calculator—A newapp to prescribe fertilizer nutrients

The Fertilizer Calculator–New App, a new revised version of the app 'Fertilizer Calculator' for better performance, was developed and released. It is an entirely offline app for making fertilizer recommendations with or without soil tests. The recommendations can be obtained by feeding inputs such as area or the number of trees, recommended doses of fertilizers for a given site, soil test report (optional) and desired fertilizer grades. It works for both macro and micronutrients.



The results would help to use the fertilizer in an appropriate amount and in a balanced way.



Effect of technological intervention on total income

lakh/ha. Due to the technology demonstration, average agricultural income of the family increased from ₹ 1.7 lakh to ₹ 2.4 lakh, whereas the average per ha income increased from ₹ 0.80 lakh/ha to ₹ 1.23 lakh/ha. The increase in the income was attributed to average increase in the income from cereals (7.33%), pulses (77.78%), oil seeds (12.59%), vegetables (150.85%), fruits (16.67%), lac (201.52%), cattle (8.2%), goat (11.45%), poultry (6.35%), duck (4.43%), pig (7.72%) and additional income of ₹ 1540 from mushroom. The intervention also resulted in increasing employment opportunities for the farm families through mandays generation and the average number of mandays per family increased from 105 to 206.

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16. 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 Parliament 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) Horticultural 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 includes 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.

The ICAR has played a pivotal role in making

agriculture sustainable through use of eco-friendly management and innovative technologies which helped the country to achieve the production of food grains four times, horticultural crops six times, fish nine times and eggs twenty-seven times since 1951. This enabled the nation not only to be food and nutrition secure but also improved livelihood of the farmers.

ADMINISTRATION

Filling up of vacant posts

During the year, the following posts were filled up under the promotion quota: 14 Director/Joint Director cum Registrar, two Director (F)/Comptroller, five Deputy Director (F)/Chief Finance and Accounts Officer, 11 Deputy Secretary and nine Chief Administrative Officer, 21 Senior Finance and Accounts Officer, 21 Under-Secretaries, 30 Senior Administrative Officer, 12 Principal Private Secretary, 34 Administrative Officer, 24 Finance and Accounts Officer, 23 Section Officers, 12 Private Secretary, two Assistant, and three LDC at ICAR Headquarters.

Financial upgradation granted under MACP scheme

During the year, 61 eligible officers and staff of ICAR (Headquarters) were granted the benefits of financial up-gradation under the Modified Assured Career Progression scheme in accordance with the Government of India (Department of Personnel and Trainings) instructions in this regard.

Finance

The Revised Estimates in respect of DARE/ICAR for 2020-21 was ₹ 7762.38 crores. An internal resources of ₹ 273.40 crores (including interest on Loans & Advances, income from Revolving Fund Schemes and interest on Short Term Deposits) was generated during the year 2020-21. The total allocation Budget Estimates for 2021-22 is ₹ 8513.62 crores.

INTELLECTUAL PROPERTY AND TECHNOLOGY MANAGEMENT UNIT

Innovation Management

Patents: During the period under report 70 new patent applications were filed in different sectors of agriculture at Indian Patent Office (IPO). Filing of applications has been rising since 2017-18. Further, ICAR's cumulative number of granted patents has risen to 408 with grant of 52 patents by IPO from 26 ICAR institutes.

Varietal registrations: Plant Varieties and Farmers' Rights Authority (PPV&FRA) granted registration certificates for 58 varieties (55 extant and 3 new) during this period. The cumulative figure of registered varieties is 1,360.

Copyrights: Research outcomes including software, books, research reports and other creative activities were protected under copyright act by filing 59 applications. A total of 301 copyrights have been registered from different ICAR institutes.

Designs: Sixteen applications were filed by ICAR-CIFT, Cochin, ICAR-CMFRI, Cochin, NINFET, Kolkata, and ICAR-NRC on Mithun, Nagaland. These included: (i) Fish freshness sensor; (ii) Fish smoking kiln; (iii) Hot air assisted continuous infrared dryer; (iv) Meat and shell separating machine for clams; and (v) Banana pseudo-stem fiber extractor. A total of 73 filed design applications have been registered.

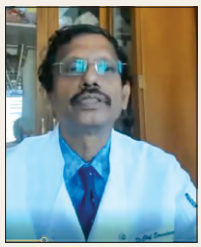
Trademarks: Twenty two Trademark applications were filed in different products and brand names, viz. *CAFRI Krishivaniki, CAMMiN, CIFRI ARGCURE, DCFR Aqua FSD fish anaesthetic, Fish Tanavhari, Brahmavarta,*

National Dialogue on Innovative Food for Hospitality Industry—ICAR Industry Interface

Intellectual Property and Technology Management (IP&TM) Unit of ICAR had organized a virtual National Dialogue on Innovative Food for Hospitality Industry on 22 June 2021. The objective of this programme is to bring on board all the stakeholders including chefs, industry and scientists working in innovative technology related to food value chain on one platform. In his inaugural address, Dr Trilochan Mohapatra, Secretary (DARE) and Director General (ICAR) emphasized on the needs of food and hospitality industry and share the views of Hon'ble Prime Minister, who had suggested to continuously organizing such programmes to support this sector.

Chef Manjit Singh Gill, President of the Indian Federation of Culinary Associations (IFCA) emphasized that the concept of *farm-to-fork* should be reinvented for providing more scope to a Chefs and Agricultural Scientists to interact and work together in a structured manner/partnership. The food processing products and processes related to Dairy, Fishery, Horticulture, Meat, and Crops Specific Products were presented by concerned ICAR institute Directors, viz. ICAR-NDRI, Karnal; IIMR, Hyderabad; CIFT, Cochin; IIHR, Bengaluru; NRCM, Hyderabad; IARI, New Delhi through detailed presentations

Dr Chef P Soundarajan, General Secretary of IFCA; Chairman, Marketing Committee-World Chefs; and Corporate Executive Chef at Club Mahindra Holidays and Resorts had suggested to the Council to be the part of Chefs associations and Hospitality industry for the betterment of farmers and food industry stakeholders.



To know the issues of food and hospitality industry different stakeholders were invited to discuss on product quality standards for improved nutrition, health and wellbeing. They have shared their views and experiences. More than 250 Scientists, Start-ups, Manufacturers, Students and Hospitality Industry Professionals participated in the Dialogue.

Patent applications filed at Indian Patent Office for various ICAR Institutes

Subject area	Name of Innovation/Technology/ Products
Animal Health and Nutrition	Antimicrobial activity of piggery waste medicinal maggots; Method and medium for *in vitro* production of Sex Specific Embryos; Method of preparing mineral block added with environment friendly materials; modified vaccine construct for EHV1; Monoclonal antibody based immune assay for detection of equine influenza (H3N8) antigen; Novel probiotic formulations to improve the growth and health of buffalo calves; NRCP-Nucleic acid based diagnosis of Porcine Reproductive and Respiratory Syndrome (PRRS) virus infection in pigs; Peptide sequences and epitope specific antibodies for detection of bovine anti-mullerian hormone (bAMH); Recombinant polyclonal monospecific antibodies-based immuno-diagnostics for *peste des petits* ruminants (PPR) surveillance; Urine based pregnancy detection method for ruminant livestock animals etc.
Food Processing	Development of pH-controller based automated endo-exo unit for dhai Label for indicating freshness of Indian dairy products; Process for preparation of milk protein fortified eggless muffins; Process for production of antimicrobial coagulant formulation for making extended shelf-life paneer; Encapsulated curcumin in microcapsules for use as food ingredient; Efficient methodology for natural vitamin extraction from edible vegetable oils; Hydro, hydro-thermal and thermal near infrared rays treatments to reduce rancidity in pearl millet flour; Methods for production of chicken having low cholesterol content in serum and eggs; Frozen mutton haleem balls; Portable meat production and retailing facility for sheep and goats; Paper strip sensor for detection of *E.coli* and Total Plate Count (TPC) in milk using PANIPAC; Rapid antimicrobial susceptibility assay for detection of extended spectrum etc.
Farm Machinery	Device and method for unmanned harvesting of nut and fruit; Harvesting mechanism of grain sorghum and alike; Hybrid solar dryer for drying of agricultural commodities; Mechanism for cutting and windrowing of pigeon pea crop and alike; Plant detection based automatic fertilizer dispensing mechanism; Precision pneumatic seed metering mechanism for hill dropping; Remote controlled Turing mechanism of power tiller with safety feature, Straw cutting and handling mechanism etc.
Fish (Aqua/Marine) Products and Processes	Apparatus and method for gravity flow regulated re-circulatory mariculture system and rearing marine species therein; Closed aquaculture system using upwelling flow for brood stocking; Compacted dampish air permeability transportation method of sea weeds species; Composition, protocol and diagnostic kit for identification of bacterial pathogen *Lactococcus garvieae*; Breeding, nurturing and rearing mollusks; Design and operation of a system for the breeding and initial larval rearing of black soldier fly *Hermetia illucens*; Living juvenile lobster transportation method and apparatus; Long-distance transportation of live post-larval marine finfish; System and sustainable improved method for integrated culturing marine finfish; System for year-round repeated breeding and higher robust fry production of *Golden Mahseer* etc.
Plant Nutrition and Protection	Compositions for dissolving mealybug wax; Enriched process to produced potassium; Enriched compost from low-grade silicate minerals or potassium bearing mineral; Antimicrobial composition for coating rhizomes and tubers; Insect trapping device with a combination of light and pheromone; *In-vitro* engineering of bio-immune formulation for inducing *Fusarium* wilt tolerance in banana plants; Novel DUF740 polynucleotide associated with multiple stress tolerance form Rice; Shatpad-banana-a herbal repellent formulation for *Odoipourus longicollis* etc.

KaMilk, NINFET Power, Preg-D, Spiisry, Shining Barb, Srinidhi, Vanashree etc. Total of 189 trademark applications have been filed by 27 ICAR institutes.

Capacity building activities: To create awareness in the area of innovation management and technology transfer, different ICAR institutes have organized various capacity building programmes at institute/zonal/ national level. In this process, 25 ICAR institutes organized 83 awareness generation programs/interface/ product-specific meets/workshops/seminars. About 4,995 scientists/researchers/business professionals/ farmers/social workers participated and benefited from these programmes.

Review-cum-Sensitization workshop of ZTMUs/ ITMUs/PMEs under NAIF Scheme: The Review cum Sensitization workshop was held from 5-11 October 2021. All Review cum Sensitization workshop of ZTMUs/ITMUs/PMEs have participated in the

Important innovations commercialized to Public and Private Organizations

Subject area	Innovations/ Know-how/Technology Commercialized
Animal Products and Processes	Arjuna Herbal Ghee; fish and chicken sausages; milk protein enriched iron fortified bajra biscuit; milk-based spray dried nano-encapsulated curcumin formulation; Quality testing of pork products etc.
Crop Production and Process Technologies	Aqueous formulation of *Spodoptera frugiperda* nucleopolyhedrovirus (SpfrNPV) NBAIR strain for the management of FAW, Arka Dorsolure-F technology; Biopesticide *T. viride, P. fluorescens* 1% W.P.; cow-urine based herbal plant growth regulator; Embryogenic cell suspensions for mass multiplication of Banana (cv Elakki balle); Herbal based Repellant for Termites on woody trees-REPTER; Micronutrient composition for ginger and a process for its preparation (for soil *p*H<7) etc.
Farm Machinery and Tools	CRIJAF jute seeder; Dal mill and multipurpose mini grain mill; Deep furrow sugarcane cutter planter; Harvesters for Mango/Sapota/Lime; Motorized double headed sugarcane single bud cutting machine; NINFET SATHI – a retting accelerator of jute and mesta; Ozone based Fruits and Vegetable Washer-cum-Purifier (Ozo-C); Portable Smart Ultraviolet-C Disinfection System (UViC); Tractor operated cassava stake cutter planter etc.
Fish (Aqua/ Marine) Products and Processes	Fish/shrimp feed from fishery waste/by products; FRP carp hatchery; Live fish carrier system and method of transportation; Nutraceuticals Cadalmin Immunoboost extract; Formulation to control parasitic infestations in fish, Fish waste to wealth; CIBA-Planktonplus and CIBA-Hortiplus; CIBAMOX - Water Probiotic Technology; CIFRI Argcure etc.
Fruit and Vegetable Based Food Products	Banana fig, flour and flower pickle; Cane jam production from sugarcane juice; Coconut chips; Foam mat dried coconut milk powder; Glutin based bajra and maize atta; Nutritious functional chapatti flour; Process for extraction of pomegranate seed oil; Process for manufacturing of nutmeg pericarp taffy; Ready to constitute makhana kheer mix etc.
Post-Harvest Technologies	Preparation of particle boards; Quality and Lot Wise Analysis of Cotton Fully Pressed (FP) Bales; Standardized liquid jaggery process; banana fibre based composite materials and preparation of Microcrystalline Cellulose (MCC); Technology for making Specialty filter paper from bleached cotton linter and production of cane dietary fibre food products etc.
Seed and Planting Material	Arka Khyathi chilli Hybrid; Bhima Dark Red onion variety; Kashi Nidhi Cowpea variety; CR Dhan 507 Rice variety; DMRH 1301 Mustard variety; HD 3086 Wheat variety; Okra Advanced Breeding line IIHR 385-5-1; Pusa Basmati-1692; Sorghum hybrid CSH 24 MF; Turmeric variety IISR Alleppey supreme; VL Maize Hybrid 57, etc.

workshop. The objective of the meeting was to sensitize the participants about the guidelines developed under this scheme, operational issues, online updating of IP data on KRISHI portal, issues regarding admin and finance besides review of work done at different institutes. All the ZTMUs presented their progress and also discussed the challenges in technology transfer. It was stressed that as per the guidelines Agrinnovate India Ltd, is the nodal agency of the technology transfer of all ICAR technologies. It was also emphasized that with the fast changing IP&Tech Management ecosystem there is a need to revisit guidelines.

Technology transfer/commercialization: The period also witnessed increased activities in commercialization/licensing by ICAR institutes through Agri-Innovate India Limited (AgIn) and on their own. Accordingly, this year, 575 such licensing agreements were signed with 452 public-private organizations and entrepreneurs. In this process, about 37 ICAR institutes were involved from different agri-based sectors including Animal Products and Processes (61), Crop Production and Process Technologies (133), Farm Machines and Tools (40), Fish (Marine/Aqua) Production and Processes (30), Crop, Fruit and Vegetable Based Food Products (51), Post-Harvest Technologies (15) and Seed and Planting Material (245).

Professional service: Thirty-five ICAR institutions in different Subject Matter Divisions have entered into 417 agreements for consultancy/contract research and services with 240 public and/or private organizations.

Agri-business Incubation (ABI): To accelerate the business and entrepreneurship development in agriculture sector, 50 ABI centers have been supported by Council at various institutes. These centers had incubated 361 entrepreneurs for development of innovative agri-business. These efforts, motivated 193 entrepreneurs to initiate their own business. To provide awareness and training on agri-business enterprises 127 Entrepreneur Development Programme (EDPs) were organized by these centers. These centers were also visited by 1,522 technology seekers/inventors/ business people/VIP/VVIP/International guests.

Technology licensing activities at ICAR institutes

Progressive Use of Hindi

Various useful programs for the farmers are being organized by the institutes of the Council in Hindi and Regional Languages. All activities related to KVK's located in Hindi Speaking area and agriculture extension activities are also being performed in Hindi and Regional Languages. Various publications on different subjects like agriculture science, animal and fishery science and horticulture science are being brought out in Hindi and Regional Languages by the Council and its Institutes.

With a view to provide knowledge of various technologies on agriculture and wider publicity thereof, magazines like *Kheti* and *Phal-Phool* are being published regularly. In-house journal of ICAR Headquarters *Rajbhasha Aalok* is being published regularly. This magazine includes articles on scientific subjects and governments 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 the year 2020 was released on 16 July 2021 through video conferencing by the Hon'ble Union Minister of Agriculture and Farmer's 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 142. During the period under review, 4 meetings of official language Implementation committee were conducted on 15 December 2020; 10 March 2021; 23 June 2021; and 29 September 2021 respectively.

In most of the ICAR Institutes/Centres, official language implementation committees have been constituted and meetings thereof are being conducted regularly. Proceedings 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 report is sent on-line to the Regional Implementation Office, Department of Official Language, Government of India. The quarterly progress reports received from various Institutes are reviewed and suggestions are given to them for effective implementation. ICAR is participating regularly in TOLIC's meetings. First Hindi Workshop for the period under report in ICAR Headquarters was organised on 24 December 2020 for private secretaries/personal assistants/stenographers on "Use of simple Hindi in day-to-day official work through E-tools as per official language policy and rules". Second workshop was conducted on 9 March 2021 for the senior officers. Third Hindi Workshop was organised by Indian Sugarcane Institute, Lucknow on 16–17 March 2021 on "Aatmnirbhar Bharat: Vocal for Local", wherein ICAR Headquarters was co-organiser. More than 250 participants from various institutes/directorates/centres/ bureaus all over the country participated in this workshop. In this seminar, 10–12 speakers delivered lectures on various subjects. Fourth workshop was organiged on 17 September 2021 for the section officers, on "The use of official work in Hindi through E-tools".

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. "Rajbhasha Ullas Pakhwara" was organized at Council's Headquarters from 14 September 2021 to 29 September 2021. On this occasion, the inspiring messages of Hon'ble Union and State Ministers for Agriculture and Farmers Welfare were issued. The Director General also issued an appeal thereby urging all officers/employees to do their maximum official work in Hindi.Under the Cash Award Scheme of Official Language being implemented at the ICAR Headquarters, 10 personnel were given

cash awards for doing their maximum work in Hindi during the year 2020-21. Three more award schemes are being implemented by the Council at its own level; which are as follows.

Rajarshi Tandon Rajbhasha Puraskar Yojana: Under this scheme, Institutes falling under 'A', 'B' and 'C' linguistic region are awarded region-wise in different categories for excellent implementation of official language. During the year 2018-19 the following Institutes were awarded for doing their maximum work in Hindi:

Institutes	Award
I **Large Institutes**	
1. Indian Agricultural Research Institute, New Delhi	First Prize
2. Indian Sugarcane Research Institute, Lucknow	Second Prize
II **Awards to other Institutes/Centres of 'A' and 'B' Region**	
1. Central Cotton Research Institute, Nagpur	First Prize
2. National Fisheries Genetic Resource Bureau, Lucknow	Second Prize
III **Institutes/Centres of 'C' Region**	
1. Central Marine fisheries Research Institute, Cochin	First Prize
2. Sugarcane Breeding Institute, Coimbatore	Second Prize

Ganesh Shankar Vidyarthi Hindi Patrika Puraskar Yojana: This scheme is applicable for the Official Language Magazines being published by various Institutes. Under this Scheme, awards are given 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. During the year 2019-20, the Magazines of the following Institutes were awarded. Details are as under:

Name of selected magazine	Name of the Institute	Award
For A & B region Institutes		
Ikshu	Indian Sugarcane Research Institute, Lucknow	First
Him Jyoti	Cold Water Fisheries Research Institute, Bhimtal	Second
Shalihotra Darshan	Indian Veterinery Research Institute, Izzatnagar	Third
Institutes of 'C' Region		
Matsyagendha	Central Marine Fisheries Research Institute, Cochin	First
Resha Kiran	Central Jute and Allied Fibre Research Institute, Kolkata	Second

Apart from the above, the following magazines were selected for consolation prizes for their appreciable publication.

Name of selected magazine	Name of the Institute	Award
For A & B region Institutes		
Soyvrutika	Indian Institute of Soybean Research, Indore	First
Laksha	Indian Institute of Natural Resins and Gums, Ranchi	Second
Sabzikiran	Indian Institute of Vegetable Research, Varanasi	Third
Name of the Institute (for 'C' Region)		
Neelanjali	Central Inland Fisheries Research Institute, Kolkata	First

Dr. Rajendra Prasad Puraskar Yojana: Dr. Rajendra Prasad Puraskar Yojna is being implemented for encouraging to write book originally in Hindi. For the year 2020-21, following books received the award:

1. Pashuon evam Pakshiyon ke Mahatvapurna Rog evam Tikakaran
2. Fasal Jaiey Samvardhan evam Poshan Suraksha

In accordance with the instructions/orders of Official Language Department, Ministry of Home Affairs, a total of 19 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 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 in Hindi and English. Hon'ble Agriculture Minister and other Senior Officers delivered their addresses in Hindi. Their speeches were originally drafted in Hindi in the Council.

TECHNICAL COORDINATION

ICAR Director's Conference was organized on 2 July 2021 through Video Conferencing. Secretary, DARE and DG, ICAR gave a brief account of achievements of ICAR during the recent past and highlighted the efforts made by ICAR Research Institutes. The DG, ICAR urged the scientists of ICAR to strive hard to find practical and economical solutions to farmers' needs and promote locally developed technologies for the benefit of farmers. The Secretary, DARE and DG, ICAR called upon the scientists to develop and provide demand driven advisories and technologies and regularly assess impact of technologies and advisories

at the field level for higher reach and greater visibility. AS&FA, DARE/ICAR, all DDGs, ADGs, Directors, PCs and Senior Officers from ICAR Headquarters participated in the conference. During the day-long conference, various issues pertaining to the scientific, administrative, financial and other miscellaneous nature were deliberated in detail.

Meetings of the ICAR Regional Committees No. VI, VII and VIII were held through Video Conferencing. The Regional Committee Meetings held once every two years, provide an ideal platform for reviewing the status of agricultural research, education and extension in the mandated states and union territories. The Committee provided a forum for liaison and coordination among the institutes of the Indian Council of Agricultural Research (ICAR), 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, which was chaired by Secretary, DARE and DG, ICAR. The problems being faced by the states in the areas of agriculture and related fields and the technology options/ potential solutions available to be developed by the NARS system were discussed threadbare and actionable points were identified and assigned to the respective institutes/ universities/KVKs to be resolved in a targeted time frame. The action taken on the issues raised in the previous Regional Committee Meetings were also reviewed.

During the reported period, the Council provided financial support to 39 societies for the publication of Scientific Journals. In addition, societies/associations/ universities were supported for holding National Seminars/Symposia/Conferences (15 Nos) and International Seminars/Symposia/Conferences (4 Nos).

Annual Report of DARE/ICAR for the year 2020 along with review statement was laid on the table of Lok Sabha (09-02-2021) and Rajya Sabha (12-02-2021). The Annual Account and Audit Report of ICAR for the year 2019-2020 along with review and delay statement was laid on the table of Lok Sabha and Rajya Sabha on 13-02-2021 and 12-02-2021, respectively.

The Umbrella Memorandum of Understanding (UMoUs) were signed between the ICAR and host Institutions, i.e. Central/States Agricultural Universities and other Departments to co-operate in conducting research through All India Coordinated Research Projects (AICRPs)/Revolving Fund Scheme/and any other such schemes funded/sanctioned by the Council under various schemes to the Host Institution from time to time at specified location (s) under the specified Supervisor/Principal Investigator/Leader of the Host Institution.Total 50 such UMoUs were signed with the Central/State Agricultural Universities.

93rd Foundation day of ICAR and award ceremony

The Indian Council of Agricultural Research has been recognizing and rewarding the institutions, scientists, teachers, farmers and agricultural journalists every year. To commemorate 93rd Foundation Day of ICAR, the Award ceremony was organized at Krishi Bhawan, New Delhi, through video conferencing on 16 July 2021. The awards were given in 17 different categories to 63 awardees; these comprised 39 scientists (including 10 women) and 11 farmers (including 2 women farmers). It is heartening to note that of the 39 scientists 10 were women.

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17. Supporting Basic and Strategic Research

The 'National Agricultural Science Fund' supports basic and strategic research in agriculture with an outlay of ₹ 206.5 crore during the reported period. The project aims at (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) Organizations of workshop, seminars, conferences, etc. to create awareness, prioritization, scientific popularization and related issues. The scheme has already funded 215 projects, mostly in consortium mode. At present 78 projects are in operation, out of which 73 are multi-institutional in nature. In addition to the current component of basic and strategic research in agriculture under different areas, based on the recommendations of ICAR Peer Review Committee, Outcome Review of ICAR schemes and Impact Evaluation of Central Sector Schemes of ICAR by Third Party, five new components, viz. Translational Research, Research in International Collaboration, Extramural Grant for Research, Scientific Validation of Farmers' Innovations and Promoting Agri-Start-ups, was also proposed in SFC memorandum of NASF for the period 2021–22 to 2025–26 for wider coverage, more visibility and outcome of the scheme.

A total of 10 new projects were approved during the reporting period. NASF also evaluated the new pre proposals received under seven strategic areas of Call IX the pre proposals and shortlisted 167 pre proposals for seeking the full proposals for further review. One meeting of the Chairpersons of the various expert committees was also held on 6 August, 2021 under the Chairmanship of Secretary, DARE and DG, ICAR for finalization of modalities for funding the projects under Call IX.

Salient achievements

During 2020–21, besides having more than 55 research publications in reputed journals, NASF had two patents and nine technologies. The research highlights of some selected projects have been summarized here:

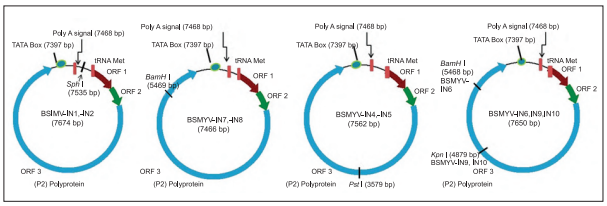
Phenomics of moisture deficit stress tolerance in rice and wheat: ML and AI aided Computer Vision phenotyping methods such as SpikeSegNet for spike detection and counting in wheat, and leaf tip detection and counting methods in rice were developed at Nanaji Deshmukh Plant Phenomics Centre (NDPPC), New Delhi in collaboration with IASRI, New Delhi and IIT, Mumbai. Analysing 170 RILs of BVD109 × IR20 of rice for component traits of transpiration and WUE, three QTLs, viz. qWUE8.3 & qWUE 6.1 & qWUE 6.2 for WUE with PVE of 17.43%, 10.32% and 16.98%, respectively, were mapped on chromosome 8 and 6 under irrigated conditions. Three QTLs for day time WUE (qWUEd6.2 & qWUEd8.4 qWUEd11.5) located very close in the same location with high PVE of 17.15, 18.39, and 10.16%, respectively were separated. QTL related to night time WUE was mapped on chromosome 8 (qWUEn8.2) with high PVE% of 13.02%. Under drought stress, two QTLs for whole day transpiration rate (qTRBM6.3 & qTRPSA6.4) were mapped on chromosome 6 with high PVE value of 31.84 and 34.12%, respectively. These QTLs will be useful to elucidate molecular basis and genetic improvement of WUE in rice.

Genome editing for improvement of drought and salt tolerance in rice: Using CRISPR-Cas9 genome editing, a Zinc finger transcription factor was developed for improving salt and drought tolerance in rice. When wild type (*wt*) plants and *dst* mutants were exposed to three cycles of –90 kPa drought stress about 25% *wt* plants survived, while *dst* mutants showed 100% survival. The *dst* mutants produced significantly higher yield than *wt* plants under both non-stress and drought stress conditions. Both *wt* and *dst* mutants irrigated with 200 mM salt stress after panicle initiation recovered after 15 days were more tolerant to salt stress with more grain yield as compared with wild-type MTU1010.

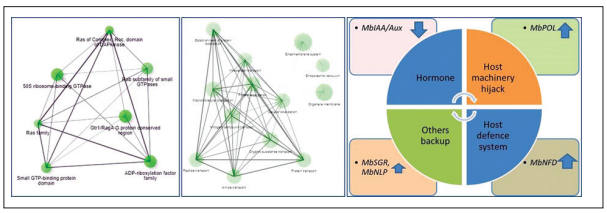
Epigenetic regulation of host-pathogen genetics in leaf rust resistance of wheat: Histone methylations (H3K4me3 and H3K27me3), context specific DNA methylation (CG, CHG and CHH and ncRNAs [miRNAs and lncRNAs]) were studied. ChIP-Seq analysis revealed large scale differential binding sites (DBS) for only H3K4me3 in the susceptible cultivar, but for both H3K4me3 and H3K27me3 in its resistant Near Isogenic Lines (NIL). A major role of context dependent CHH methylation either alone or in combination with histone methylation in regulation of gene expression was observed by BS-Seq. Demethylation-mediated high expression of genes during susceptible reaction and methylation mediated low expression during resistant reaction was conspicuous. Further, using smRNA-seq and RNA-seq, a large number of conserved and novel miRNAs were identified, which differed for the gene Lr28 in the background of wheat cultivar HD2329. The

number of miRNAs downregulated in the resistant NIL exceeded the number of upregulated miRNAs, whereas reverse pattern was observed in susceptible NIL. The genetics of the pathogen (*Puccinia triticina*) was also studied in *P. triticina* wherein 28 candidate effectors and 11 ncRNAs were identified and validated using qRT-PCR analysis.

Population diversity of banana streak viruses (BSV) and the mechanisms of resistance to BSV in diploid seedy banana of North East India: Full genome sequences of seven episomal banana streak MY virus (BSMYV) isolates including two novel variants and two novel banana streak IM virus (BSIMV) isolates sampled from Centre of Banana Diversity and Sympatry (North East Region: NER, India) were deciphered. The BSMYV genetic variants in addition to pathogenically distinct were also significantly different in terms of gene products and IGR. This study reports the infection of pathogenically and genetically distinct BSIMV on triploid banana hybrids in NER India. The infectious partial tandem dimeric construct of banana streak MY virus (BSMYV) was used to prove pathogenicity on banana genotypes AAA, AB, ABB and BB. The agro inoculated diploid banana genotype Bhimkol (BB) from NER, India showed delayed infection (9 months post-agro inoculation). *De novo* transcriptome and differential gene expression (DEG) analysis of agro infected (BB_Symptomic) and mock-inoculated Bhimkol identified four major clusters. DEGs enrichment and qPCR validation showed calcineurin B-like gene (*MbCLP*), nuclear fusion defective gene (*MbNFD*) associated with small G protein signalling and protein localization were significantly upregulated in diploid Bhimkol (BB) showing delayed infection. The network enrichment analysis of DEGs further elucidated the role of these two significant hubs (small G protein interaction and protein localization) in coping the subcellular damage, the possible mechanism of delaying BSMYV infection in diploid *Musa balbisiana* cv. Bhimkol (BB). This study suggested that the co-ordination of the host defense system (protein localization), signalling



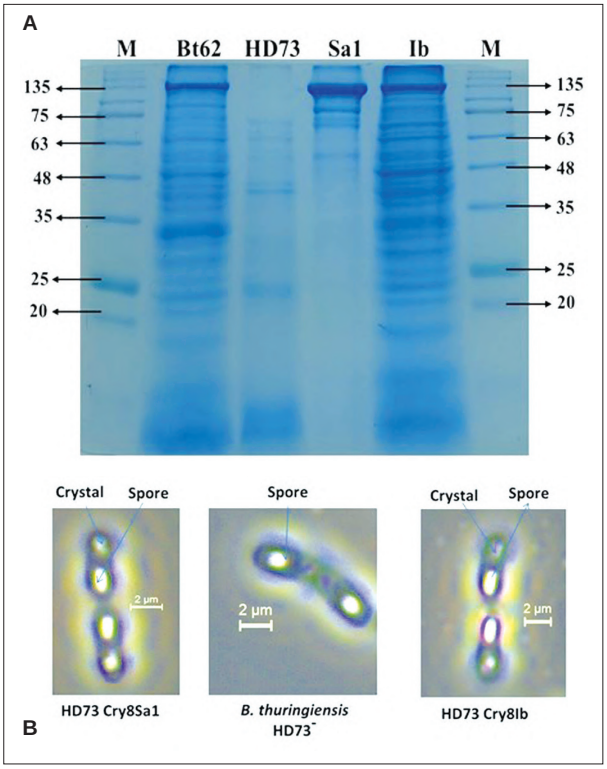
Genome maps of two BSIMV and seven BSMYV isolates sampled from natural triploid banana hybrids in NER India.



Two significant hubs identified using network enrichment analysis and model of delayed BSMYV infection

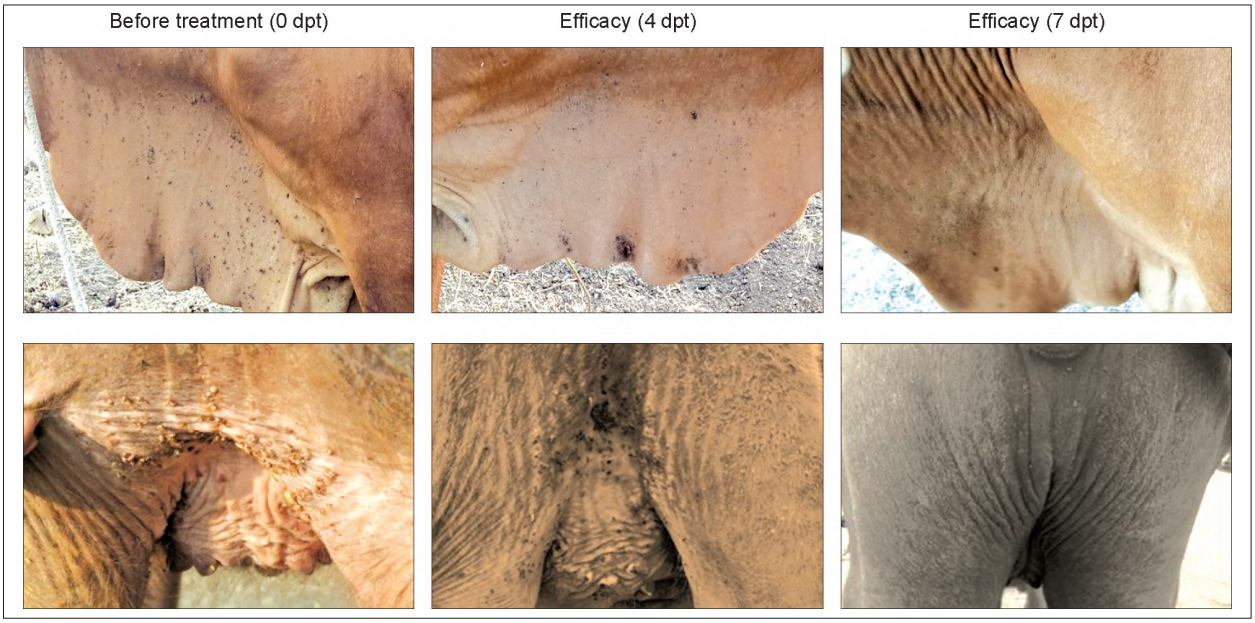
(hormone and small G proteins) and host machinery hijack play an important role in fighting BSMYV infection, and finally the delayed infection or resistance breakdown.

Deploying novel cry toxin holotype genes for white grub (*Holotrichia serrata*) resistance in sugarcane and groundnut: Whole genome sequencing of *Bacillus thuringiensis* isolate, Bt 62 genome, revealed the presence of *cry8Sa1* and *cry8Ib* genes. Bt 62 isolate was found toxic to white grub *Holotrichia serrata*. The cloning, purification and expression of *cry8* toxins genes (*cry8Sa1* and *cry8Ib*) individually in crystal negative (acrystalliferous) *B. thuringiensis* HD73$^-$ strain was performed. The SDS PAGE analysis revealed that Cry8Sa1 and Cry8Ib toxin was successfully expressed in the acrystalliferous Bt strain. The bioassay results indicated that Cry8Sa1 toxin exhibited significantly higher insect mortality of up to 90% as compared to 60% mortality obtained with Cry8Ib toxin.

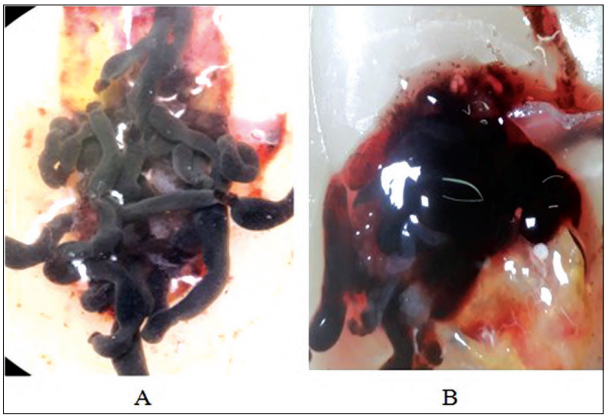


(A) SDS-PAGE analysis of *Bacillus thuringiensis* isolate Bt 62 Cry protein. Lane 1 and 6: 10–250 kDa protein marker, 2: Bt 62 spore crystal mixture protein profile (wild type), 3: *Bacillus* HD73$^-$ (acrytalliferous) strain, 4: cry8Sa1 in HD73$^-$ spore crystal mixture protein profile, and 5: cry8Ib in HD73$^-$ spore crystal mixture protein profile. (B) Phase contrast microscopic observation of acrytalliferous *Bacillus* producing cry8 (cry8Sa1 and cry8Ib) crystal toxins.

Identification of anti-tick lead phytochemicals for the control of acaricide resistant ticks: Two flowable (F5 and F10) and a cream based anti-tick phyto formulants, with 80–90% efficacy both in *in vitro* and *in vivo* conditions were identified. The formulation-induced impact on vital organs of treated ticks was evaluated, which revealed a highly fragile gut with leakage of ingested host blood after 12 h and complete



Field efficacy of the formulations in multi-locational field trials 7 days post treatment (dpt)

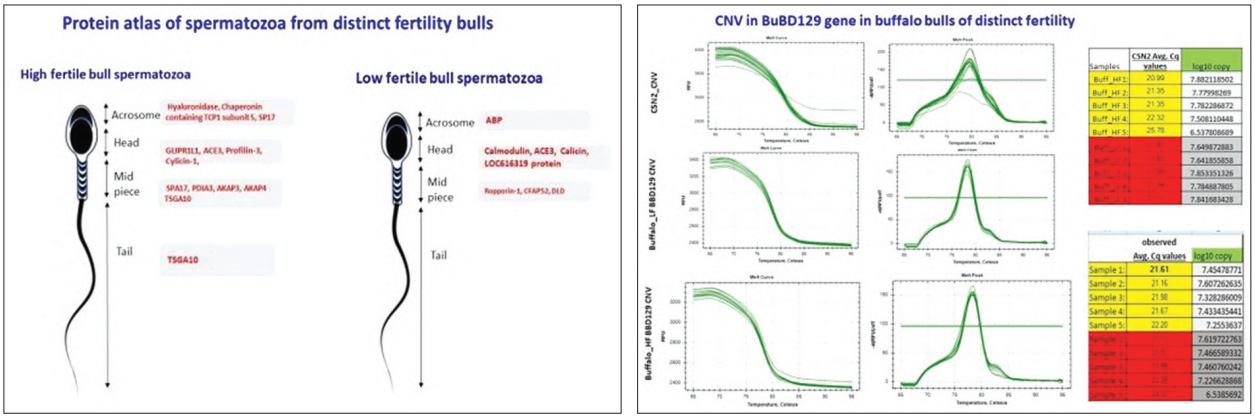


Effect of F10 formulation on the gross structure of gut of treated ticks. (A) Gut ofnormal ticks; (B) Damaged gut of treated ticks

disorganization of cellular architecture after 48 h of treatment. The efficacy data of the formulations, flowable (F10) and natural cream (NC) was validated on animals following standardized protocol of topical application in multi-locational field trials in Uttar Pradesh, Uttarakhand, Maharashtra and Telangana. The direct effect of treatment was observed in the form of dried, black and paralyzed ticks on the treated animals after 3–4 days of application. After 7 days of application, the safe and stable phyto formulations provided > 85% activity against acaricide-resistant field ticks.

Generation of BMPR-1B gene edited goats using CRISPR/Cas technology: The pcDNA3.1 vector containing spCas9-HF1 gene was constructed and $FecX^{Gr}$ and $FecX^{O}$ specific primers were designed to synthesize DNA template of sgRNA followed by *in vitro* transcription and purification of sgRNA. To use as HDR template, Asymmetric ssODNs for $FecX^{Gr}$ and $FecX^{O}$ were designed. CRISPR components in the RNP formats along with ssODNs were electroporated into the *in vitro* matured oocytes followed by *in vitro* fertilization and culture for 7 days for further embryonic development. Amplified genomic DNA was subjected to T7E1 assay to determine the genome editing. The editing efficiency for $FecX^{Gr}$ and $FecX^{O}$ edited goat embryos was 58.90 and 50.94%, respectively. The mono and bi-allelic percentage as revealed in the *in vitro* cleavage assay for $FecX^{Gr}$ edited embryos was 79.17 and 20.83%, respectively; and for $FecX^{O}$ edited embryos 76.54 and 23.46%, respectively.

Improving the usability of buffalo spermatozoa by sperm surface remodelling and immune acceptance in female reproductive tract: Whole proteomic profile of high and low fertile buffalo bull spermatozoa, using label free LC-MS/MS analysis could identify1,064 (85.2%) and 968 (77.5%) proteins in high and low fertility group spermatozoa, respectively out of which 782 (62.6%) proteins were common to both groups and 349 proteins were differentially-expressed between the high and low fertility spermatozoa. One- hundred-ninety four proteins were up-regulated and 155 proteins were down-regulated in high fertility spermatozoa as compared to low fertility spermatozoa. The proteins like AKAP4, AKAP3, SP17, PDIA3, Testis specific 10, GLIPR1-like protein and cylicin-1, etc. were highly expressed in high fertile bull whereas Angiotensin-converting enzyme, Acrosin-binding protein, Calmodulin, Cilia and flagella associated protein 52, dihydrolipoyl dehydrogenase, growth hormone inducible transmembrane protein etc., were highly upregulated in low fertility bulls. Double digest restriction-site associated (ddRAD) sequencing of the gDNA of 10 Murrah buffalo bulls, 5 each from high and low fertile categories, could identify 415 SNPs in 42 candidate genes affecting immune response traits. Copy number variations (CNVs) studies of CD52, CD55, CD59, CD46, PTGS1 and Man2a2 genes, selected on the basis of their immune related function, could not establish any major differences of fertility between the two groups of animals. BNCSP (buffalo non-capacitated sperm protein) and BCSP (buffalo capacitated sperm



Buffalo spermatozoa by sperm surface remodelling

protein) were used to develop buffalo sperm surface lectome map of buffalo spermatozoa.

Performance of elite buffalo bulls developed through animal cloning: Three live and healthy cloned calves were born during the reporting period, and five pregnancies are continuing with more than 6 months of gestation. To improve the cloning efficiency, effects of trichostatin-A (TSA) and 5-aza-2'-deoxycytidine on cloned embryos production and its quality were evaluated and combination of these drugs significantly improved cloned embryo production. Further, semen of cloned bulls was utilized for artificial insemination (AI) to generate data on fertility. The preliminary data, generated on methylation pattern of cloned vs IVF generated embryos revealed similar pattern in both source of embryos. The body weight, haematology, serum biochemistry and telomere length of 8 clones born during 2019–20 were evaluated and all parameters were comparable with age matched AI born animals. A total of 15,000 frozen semen doses of cloned bull Hisar-Gaurav and 3,000 of Assamese buffalo cloned bull were produced. The fresh semen of Hisar-Gaurav in 15 oestrous synchronised female buffalo was used in experimental herd out of which 13 got pregnant.

Captive breeding of hilsa, *Tenualosa ilisha:* Five-day-old hatchling of hilsa, reared in freshwater pond (0.003 ha) for 60 days, exhibited better growth (2.39±0.24 g) and survival (30%) in ponds supplemented with Plankton^{Plus} (75 ppm) along with mustard cake (75 ppm) as plankton booster compared to mustard cake (control) (body weight 1.31±0.09 g; survival 18%). Nursery reared hilsa fry (1.84±0.30 g/5.58±0.40 cm) stocked in grow-out pond (0.15 ha) @ 14,000/ha at Kakdwip were fed with slow sinking crumbled feed (CP-35% and fat 12%). Fries (50; 7.12±2.21 g/9.09±0.73 cm), recovered after the cyclone Yaas, gained body weight/length of 35.95±1.73 g/14.7±0.29 cm in 120 days. Four days old spawn (wild bloodstock yielded) exhibited 40% survival in 44 days to fry (19.6 mm/0.06 g); and 126 days to fingerlings (66 mm/2.52 g, 44% survival). At Rahara, fingerlings stocked in ponds (0.1 and 0.4 ha) grew to 9.48–15.8 g in 30 days. Hilsa pond rearing facility (0.4 ha) was established at Kolaghat and stocked with 165 fingerlings (7.6±1.5 g/8.78±0.48 cm). After Yaas, hilsa broodstock development (n=25; 158.84±12.50 g/22.85±0.72 cm) was reinitiated in 0.15 ha brackish water pond. Interestingly, similar gonadal maturation (stage-II) was recorded during 03.09.21 to 04.10.2021 in both wild and captive female hilsa; however, captive (GSI: 2.24±0.025) male was one stage ahead to wild (GSI: 0.768±0.002) stock.

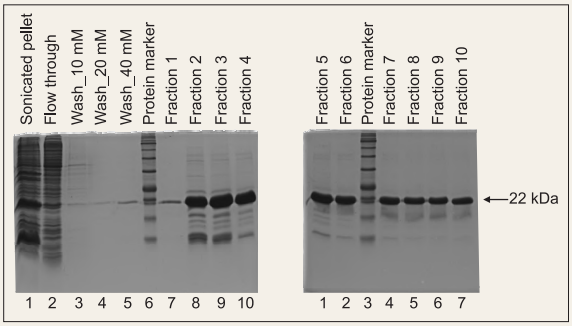
Captive breeding of hilsa

Porcine reproductive and respiratory syndrome (PRRS) virus in pigs: The nucleocapsid protein (N) of PRRSV genotype 2 Indian isolate (PRRS/MZ/IND/109A/18, Genbank#MK315210.1) was successfully cloned into pET vector. The codon optimized PRRSV N gene was expressed successfully in pET30a vector. The recombinant N protein was purified using the Ni-NTA purification system and optimized through indirect ELISA for detection of antibody against PRRSV in field porcine sera samples. The protocol used more field sera samples collected from field outbreaks of PRRS in Mizoram and comparison of the results with the commercial kit (PrioCHECK PRRSV ab porcine kit from Prionics) is under validation.

Dietary trace minerals in animals under stress conditions: The effect of dietary selenium levels on trace mineral metabolism, antioxidant response and mRNA expression of heat shock protein under heat stress condition in goats was assessed. Higher dietary selenium

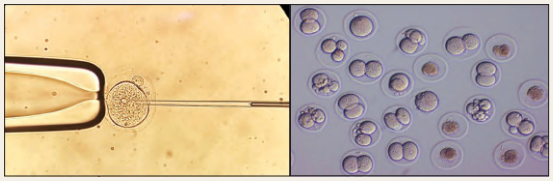
Purification of PRRSV_rN protein

Expression and purification of N-terminal and C-terminal His6-tagged nucleocapsid protein of PRRSV. pET30a(+)_N plasmid was grown and protein were extracted after induction (with 0.1 mM of IPTG at 25°C). Induced cells were lysed and N protein was purified through His60 Ni Gravity Columns (TakaraBio, Cat. 635657) followed by manufacturer's protocol. Elution was carried out by collecting 1 ml fraction (up to 10 fraction collected). Same volume of protein samples were analysed into SDS-PAGE (15%) and stained with Coomassie Brilliant Blue. Desired protein is showing band of 22 kDa when compared with the colour protein marker.



CRISPR/CAS9 guided functional analysis of genes regulating early embryonic survival in buffalo

For targeted editing of COX-2, PTGES and PTGFS genes confluent buffalo endometrial epithelial cells (70–80% confluency) were transfected with COX-2, PTGES and PTGFS CRISPR/Cas9 constructs. After 48 hr, culture was kept for puromycin selection for 12 days. A significant decrease in $PGF_{2\alpha}$ and PGE_2 concentrations following CRISPR/Cas9 based editing of COX-2, PTGES and PTGFS genes was observed. Significant decrease was observed in COX-2, PTGES and PTGFS mRNA expression following editing of COX-2, PTGES and PTGFS genes. A method for pure culture of epithelial cells was developed by differential attachment method. CRISPR-CAS9 vectors were constructed, which contain sequences for target sgRNA and Cas9 for efficient knockdown in host cells. Successful transfection of the constructed CRISPR/Cas9 vectors using lipofectamine was achieved in mouse endometrial epithelial cells at 40% transfection efficiency.



Microinjection of vector against PTGES in zygotes. Zygotes were microinjected with PX-458 vector containing sgRNA against PTGES. Embryos after 12–24 h of *in vitro* culture were graded as useful when developed to 2-cell stage.

improved trace mineral metabolism, antioxidant response and favourably affect mRNA expression of Hsp70 in goats under heat stress conditions indicating the potential of Se in conferring better adaptation of animals to higher environmental temperatures. Heat stress (HS) increased urinary excretion of trace minerals namely, Cu, Zn, and Mn; however, higher dietary Se reduced heat-stress-induced trace minerals excretion from the body. The serum concentration of Se, Zn, and Cu and the activity of GPx, SOD, catalase antioxidant enzymes reduced and GSH improved in 1,154 and 2,018 ppb Se fed goats under HS condition. Exposure to heat stress for a prolonged period of 21 days down-regulated mRNA expression of Hsp70 in goats, which might be indicative of de-compensatory phenomenon. However, feeding higher Se under HS conditions could maintain the mRNA expression of Hsp70 equal to TN conditions.

Volatile organic compounds for safe management of potato, onion and tomato in storage: The database for the key volatile organic compounds (VOCs) generated by onion infected with *Erwinia carotovora*, *Aspergillus flavus*, and *Aspergillus niger*, during storage at different storage conditions (4°C, 8°C, 15°C, and RT) was generated. VOCs change with the storage conditions and type of microbial infection and commodity. The number of VOCs emanating from bacterial and fungal infections ranged from 34–178 and number of VOCs emanating during storage diminished as the storage temperature decreased, irrespective of infection, indicating slowing down of metabolic activities in both the substrate and microbes. The cluster heat map of the group average of the data matrix classified and visualized the dominant VOCs among control and infected samples. Multivariate data analysis of the VOCs suggested that Ortho-PLS-DA was better in classifying different VOCs emanated from the commodity at different storage conditions, infected with different microorganisms. An embedded software on ARM platform was developed and successfully tested data acquisition from sensors and accordingly Derby as Embedded low-footprint RDBMS was selected for data storage. The interface of the ARM board with the data acquisition board with sensor assembly was done successfully; its initial testing was conducted.

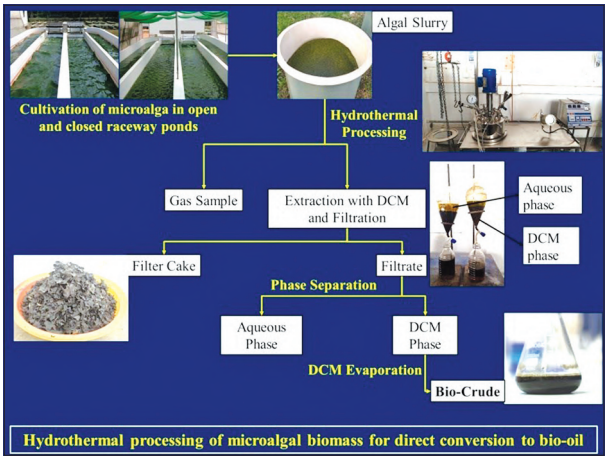
An embedded software on ARM platform

Microalgal biomass for biodiesel and other industrially important co-products: Process for bio-oil production from microalgal slurry was standardized. Bio-oil yield up to 45% of dry weight was obtained for *Chlorella minutissima* biomass, which was however, lower for protein- and carbohydrate-rich species. The Cyanobacterium *Leptolyngbya* sp BTA 477 was also explored successfully for biodiesel production. Along with SCC (sodium copper chlorophyllin), another

Bio-waste management through microbial consortia

Using potential lignoceullulolytic microbes (including bacteria, fungi, actinomycetes), "Ekcel decomposer" consortia was developed for accelerating the decomposition of different bio-waste. In addition, a drum type composting unit and shredder machines namely "Ekcel Composter" and "Ekcel Shredder" were also customized and fabricated for enhanced decomposition of organic residues. In this technique, different types of waste material like vegetable waste, kitchen waste, horticultural waste and farm waste are used for composting and quality compost, free from pathogen and nematodes was ready for field application within 25–45 days. In the field studies, beneficial effects of application of enriched compost to augment the crop productivity compared to recommended dose of fertilizer (RDF) and control were also found. A model compost unit was developed at IISS center for demonstration to the farmers, students and other stakeholders. The "Ekcel decomposer" is also being used for *in situ* decomposition of rice–wheat residue in farmers' field of Bhopal.

Ekcel decomposer



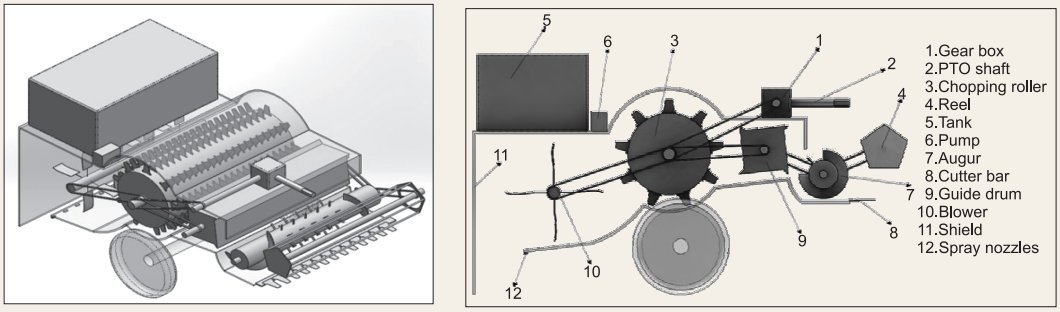
Hydrothermal processing of microalgal biomass

protocol was standardized for maximum extraction of microalgal protein from algal biomass that can be substituted in the diets of freshwater fishes as a protein supplement. Standard feed, whole microalgal biomass and extracted microalgal protein diet in the ratio of 25:25:50 proved to be the best diet for maximum growth of the freshwater fish varieties, rohu, mrigal and catla. As a by-product of trans-esterification process, crude glycerol was also obtained which was purified up to 92%.

Production of dipeptidyl peptidase-IV (DPP-IV) inhibitory peptides from milk and encapsulation: The specific hydrolysates of alpha lactalbumin and kappa casein isolated from Gir cow milk exhibited better dipeptidyl peptidase-IV (DPP-IV) inhibitory activity with

Paddy straw residues management through *in situ* microbial decomposition

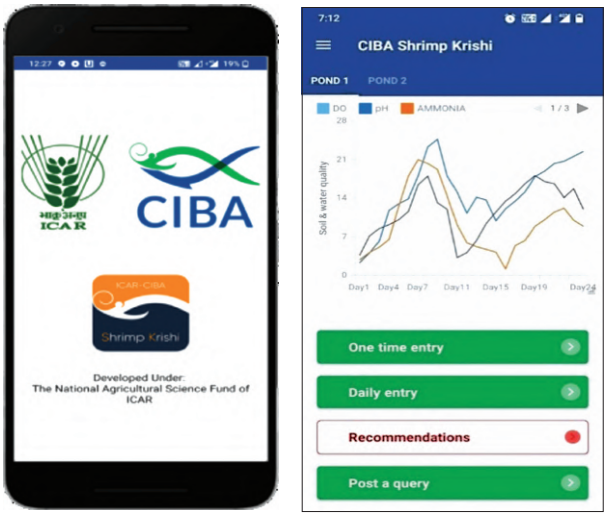
Under the field conditions microbial consortium recorded the 22% of degradation (C: N ratio reduction) after 30 days, which had the positive effect on wheat. Subsequently, NRRI fungal consortium was modified with addition of efficient silicate solubilizer and *Streptomyces* sp. and its application along with different additives (0.1% CMC or 1.0% jaggery, 2 mM concentration of $CuSO_4$, $MgSO_4$ and $MnSO_4$ and 30 kg urea per 6t straw) with sufficient moisture (field capacity) significantly increased degradation of paddy straw compared to without additives after 25 days. The development of mechanical intervention for *in-situ* management of rice-residues involved selection of optimum design values of cutting unit. The minimum cutting force (1.30 N) and cutting energy (6.85 N.mm) was observed at bevel angle 15°L, cutting angle 25°L, and cutting velocity 4.10 m/s with composite desirability of 0.983. The critical design parameters of inoculum application system were also optimized. The conceptual design of prototype for *in situ* rice residues management was developed with cutting, conveying, chopping, and inoculum application system as the major functional components. A customized attachment of microbial inoculum applicator suitable for straw-cutter-cum-spreader was also developed.



Conceptual design of prototype machine for *in situ* rice residues management

IC_{50} value of 0.78 mg/ml and 61.6 µg/ml. The hydrolysates of alpha-lactalbumin (NEH), encapsulated in double emulsion matrix (EEH) and freeze-dried encapsulated hydolysates (FDH) revealed a higher DPP-IV inhibitory activity as compared to the non-encapsulated hydrolysate *in vitro* through simulated gastrointestinal digestion. The impact of oral administration of the encapsulated and non-encapsulated hydrolysates was also evaluated in nicotinamide-streptozotocin induced diabetic rats. Oral administration of the hydrolysates for four weeks helped in improvement of the diabetic condition in rats. A significant decrease was observed in the fasting blood glucose, TGs, total cholesterol, VLDL, LDL level with NEH, FDH and EEH fed diabetic rat compared to diabetic control. The level of liver enzymes (ALT and AST) and ALP also decreased significantly in diabetic animals by NEH, FDH and EEH intake. The level of plasma insulin and GLP-1 increased significantly in diabetic animals fed with EEH. NEH, FDH and EEH exhibited anti-diabetic properties, and the anti-diabetic potential of the EEH group was comparatively better.

Smart aquaculture model (SAM): An android based mobile application, CIBA Shrimp KrishiApp, was developed and launched for handholding the shrimp farmers to manage their farms taking customised real-time data based decisions at the farm level. The app size is 7.2 MB and it will work in android version 5.0 and above. The app is made available in English, Hindi, Tamil and Telugu languages. 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 in-built decision-making system, the app will display pond-wise status on shrimp survival, biomass, feed conversion ratio, pond water quality, and the expenditure incurred. Three expert systems, viz. shrimp feed management, water quality management and shrimp disease management, are inbuilt in the app. Based on the data fed into the app, it alerts the end-user with technical advisories whenever any deviations are noted in water quality, feeding and shrimp health. The app will 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. Moreover, it paves the way for accessing real-time bulk data from the remotely located shrimp farms to monitor and extend customized technical advisories. Two sensitization workshops were conducted respectively at Uppanar shrimp farming cluster in Cuddalore district, Tamil Nadu and Thumlapalli shrimp farm cluster in Bapatla district, Andhra Pradesh and 90 shrimp farmers were sensitized on app contents and trained on smart shrimp farming using Shrimp Krishi App.



CIBA Shrimp Krishi App

Entrepreneurship development through Farmer Led Innovations in plantation sector: Seven innovations, i.e. new cardamom variety –Njallani (Kerala), Nova nutmeg variety (Kerala), Thiruthalli—an improved variety of cardamom (Kerala), White flowered cardamom variety (Kerala), Wonder cardamom—a new variety of cardamom (Kerala), Zion Mundi-improved black pepper variety (Kerala) and tamarind de-seeding machine (Odisha) were validated at farmers' field level by ICAR-NAARM, ICAR-CPCRI and IIPM, Bengaluru. The results of the proposed hypothesis between identified variables and entrepreneurship/ innovation tested using Chi-Square analysis indicated that there is a strong association between innovation and entrepreneurship and there is no relationship between age, size of the plantation and education with entrepreneurship/innovations. Among the various existing innovation models, identified cyclic model of innovation with interconnected cycles is a suitable model for plantation sector through factor analysis. This model exhibited six characteristics namely, customer value, market factors, commercial aspects, societal value, technological aspects and economic aspects. Developed Entrepreneurship Assessment Index (EAI) based on OECD 2015 framework using 17 indicators. The EAI value was 120 and it indicated that 75% of innovators were ready to take up the entrepreneurial activities. As part of validation process, field experiments were organized for the selected farmers led innovations (FLIs) in 20 farmers' field with five replications. The validation was compared with the traditional method. The analysis indicated that out of 22 FLIs prioritized, 14 innovations are under commercialized category, four are potential to commercialize and remaining four need support for commercialization. Strategies are being prepared to upscale the FLIs based on the existing schemes in promotion of entrepreneurship development and competitor analysis of the FLIs.

ICT based extension strategies for the nutrition sensitive agriculture: Malnutrition is the most common nutritional disorder in developing countries, and it remains one of the most common causes of morbidity and mortality among children worldwide. To understand the motivation to improve health, in context of anaemia and nutritional health behaviour among farmers' nutrition

health belief model (NHBM) and to make role of agricultural extension personnel effective and efficient, acknowledge scale on agri-nutrition were developed for them. A perception scale was also developed to study perceptions of farmers and extension personnel regarding impact of climate change on nutrition. On the basis of knowledge and perception scale development, content for nutri-dense and biofortified crops (44 nutri-dense and 11 biofortified crops of different crop groups) were formulated in a concise form and presented in a crisp way for various stakeholders engaged in Agri-Nutri field. ICT mediated agriculture extension app website (agri-nutri information system): Link- http://anis.icar.gov.in: where content related with nutri-dense and biofortified crops is available for stakeholders with respect to climate, season, nutritional profile, health benefits, package of practices and value addition in different languages, i.e. Hindi, English and Odiya. It is the android application where stakeholders can install this application in their mobile system and get the information regarding all aspects of nutri-dense and biofortified crops. This system also has interactive voice response (IVR) system, which provides pre-recorded voice responses for appropriate situations to access relevant data for farmers.

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18.
Training and Capacity Building

The highlights of Training and Capacity Building of ICAR employees of all categories undertaken during reported period.

Design, development and organization of training programme on 'Accrual Accounting' for finance staff

A specialised training programme on 'Accrual Accounting' based on Training Need Identification for AF&AO/F&AO/Senior F&AO of ICAR Institutes and HQs was designed, developed and organized by ICAR-NRRI, Cuttack in coordination with HRM Unit and Finance Division, ICAR HQs in two batches during reported period in which 96 finance staff members participated, all of them got this opportunity for the first time to participate in such type of programme after joining service.

Inaugural function of online training programme on 'Accrual Accounting'

Online management development programme for PME cell incharges

An online management development programme (MDP) on PME in agricultural research projects was organized during reported period by ICAR-NAARM, Hyderabad in coordination with HRM Unit, ICAR HQs to acquaint the PME Cell Incharges with the techniques for research prioritization, monitoring and evaluation. In the said MDP, 35 PME Cell Incharges and members of PME Cell of 32 ICAR-Institutes participated, all of them got this opportunity for the first time to participate in such type of programme after joining service.

Online training on e-Office implementation

Six online trainings on e-Office implementation for all ICAR-Institutes were organized by ICAR-IASRI, New Delhi which were attended by 640 participants of various categories from different ICAR-Institutes/HQs.

Effective health management for enhancing work efficiency of employees

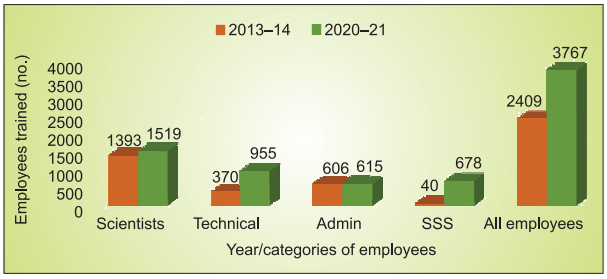
In view of acute Covid-19 Pandemic situation, ICAR-Institutes were asked to organize 1–2 days online training programme on "Effective Health Management for Enhancing Work Efficiency of ICAR Employees". Fifteen ICAR-Institutes organized such programme covering physical, mental, spiritual health along with stress management and positive thinking. About 1,200 participants attended the programme.

Impact assessment of training programmes

Impact assessment of training attended by 2,697 employees of various categories during 2018–19 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 3.89/5.00. 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-Great Extent with average rating of 3.82/5.00.

Employees trained

During the reporting period, 3,767 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 1,519, 955, 615 and 678, 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 9.0, 158.1, 1.5 and 1595% in Scientists, Technical, Administrative and Skilled Support Staff, respectively along with overall improvement of 56.4% in all the categories of employees during reported period.



Improvement in capacity building of ICAR employees with the creation of HRM Unit

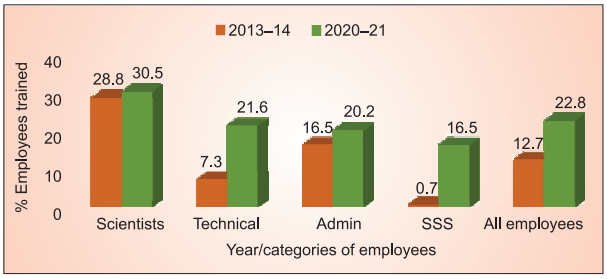
During the reporting period, Crop Science Division deputed highest number of Scientists (393) and Administrative including Finance staff (140), whereas

SMD-wise number of employees undergone training during 2020–21

SMDs/HQs	No. of employees trained					Per cent employees trained				
	Scientists	Tech.	Admin	SSS	Total	Scientists	Tech.	Admin	SSS	Total
Crop Sciences	393	174	140	106	813	23.3	12.9	17.9	8.3	16.0
Horticultural Sciences	286	196	113	145	740	40.6	33.1	34.3	30.5	35.2
NRM	299	271	108	189	867	38.2	32.4	27.4	38.6	34.6
Agricultural Education	50	15	5	0	70	31.3	18.1	5.2	0.0	17.8
Agricultural Engineering	76	71	31	54	232	37.4	29.5	25.2	48.6	34.2
Animal Sciences	204	100	108	66	478	27.3	13.4	19.5	5.2	14.4
Fisheries Sciences	187	125	83	118	513	32.1	25.6	27.7	31.6	29.4
Agricultural Extension	22	3	17	0	42	51.2	12.5	29.3	0.0	31.6
ICAR HQs	2	0	10	0	12	2.8	0.0	2.4	0.0	2.0
Total	1,519	955	615	678	3,767	30.5	21.6	20.2	16.5	22.8

NRM Division deputed the highest number of Technical (271) and Skilled Support Staff (189) for various capacity building programmes. Thus, overall, maximum number of employees were trained in NRM Division (867) followed by Crop Science Division (813), out of 3,767 employees trained in the ICAR system.

In terms of per cent employees trained under each category, Scientists (30.5%), Technical (21.6%), Administrative including Finance (20.2%) and Skilled Support Staff (16.5%) were trained in various aspects as per their training needs during 2020–21 with overall 22.8% employees across the categories who got opportunity for capacity building. This is evident that 1.7, 14.3, 3.7 and 15.8% more Scientists, Technical, Administrative including Finance and Skilled Support Staff, respectively got training opportunities during 2020–21 as compared to 2013–14 with overall improvement of 10.1% in capacity building of all the categories of employees.



Per cent employees undergone training with the creation of HRM Unit

The training programmes organised for Scientists, Technical, Administrative including Finance, and Skilled Support Staff were 156, 76, 32 and 62, respectively. Compared to 2013–14, ICAR-Institutes organized 13.4 and 1140% more training programmes for Technical and Skilled Support Staff, respectively during 2020–21. 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 (69), Crop Science and NRM Division for technical staff (17), Horticulture Division for administrative staff (10), and Agricultural Extension Division for skilled support staff (16). Moreover, maximum number of training programmes for all employees were organized by Agricultural Education Division (71) and was followed by Crop Science Division (56).

Performance of ICAR Institutes

As per ICAR HRM Policy: Training and Capacity Building, one-fourth to fifth (20–25%) of the employees in each cadre in the Institute/HQs must be trained every year so as to train all the categories of employees in 4–5 years span to develop the desired competency and improve the organizational performance. Therefore, all employees must have got at least one training opportunity in 5 years. Keeping this in mind, the said information was collected

Number of trainings organized by various SMDs during 2020–21

SMDs	Scientists (No.)	Technical staff (No.)	Administrative staff (No.)	SSS (No.)	All employees (No.)
Crop Sciences	21	17	8	10	56
Horticultural Sciences	11	10	10	13	44
NRM	13	17	3	10	43
Agricultural Education	69	1	1	0	71
Agricultural Engineering	8	10	5	4	27
Animal Sciences	27	9	2	6	44
Fisheries Sciences	5	9	3	3	20
Agricultural Extension	2	3	0	16	21
Total	156	76	32	62	326

SMD-wise per cent employees of various categories trained during 2014–20

SMDs	Scientists (%)	Technical staff (%)	Administrative staff (%)	SSS (%)	All employees (%)
Crop Sciences	84	80	83	85	83
Horticultural Sciences	84	75	77	66	76
NRM	84	77	76	66	76
Agricultural Education	83	90	90	93	88
Agricultural Engineering	91	68	79	87	80
Animal Sciences	88	67	70	71	74
Fisheries Sciences	92	80	88	72	83
Agricultural Extension	86	69	85	75	81
Overall (%)	86	76	81	75	80

from all the ICAR-Institutes. It was observed from the data that Agricultural Education Division deputed/trained 88% of the total employees in a span of 6 years during 2014–20 followed by Crop Science Division (83%). Category-wise data revealed that Fisheries Science Division deputed maximum Scientists (92%), whereas Agricultural Education Division deputed maximum Technical staff (90%), Administrative including Finance staff (90%) and Skilled Support Staff (93%) for various capacity building programmes. The analysis also revealed that 100% Scientists, Technical, Administrative and Skilled Support Staff were trained by 27, 26, 29 and 41 ICAR-Institutes, respectively during 2014–20. Out of 113 Institutes, 20 Institutes were rated as Excellent which provided training opportunity to 95–100% staff while 10 Institutes have been rated as Very Good which provided training opportunity to 90–94% staff during 2014–20. Overall, 80% of the total employees of all categories got training opportunity during 2014–20.

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APPENDIX 1

ACTIVITY PROGRAMME CLASSIFICATION

Budget Estimates (BE) and Revised Estimates (RE) for the year 2020–21 and BE 2021-22 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
		2020–21	2020–21	2021–22
		Unified Budget	Unified Budget	Unified Budget
Major Head	**'3451'**			
090	**Secretariat-Economic Services**	755.00	640.00	732.00
Major Head	**'2415'**			
80	**General**			
80.120	**Assistance to other institutions**			
01	**Grant-in-Aid Central Agricultural University Imphal**			
010031	Grants in Aid General	-	-	-
010035	Grants for creation of Capital Assets	-	-	-
010036	Grants in Aid Salaries	-	-	-
02	**Grant-in-Aid Central Agricultural University Bundelkhand**			
020031	Grants in Aid General	500.00	550.00	550.00
020035	Grants for creation of Capital Assets	10000.00	8900.00	9695.00
020036	Grants in Aid Salaries	500.00	834.00	850.00
03	**Grant-in-Aid Central Agricultural University Bihar**			
030031	Grants in Aid General	1100.00	1100.00	1500.00
030035	Grants for creation of Capital Assets	6000.00	3968.00	4500.00
030036	Grants in Aid Salaries	7490.00	8500.00	9000.00
05	**Grants-in-Aids to National Academy of Agricultural Sciences and Indian Agricultural Universities Association**			
050031	Grants in 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	900.00
060035	Grants for creation of Capital Assets	500.00	200.00	350.00
060036	Grants in Aid Salaries	658.00	600.00	650.00
80.798	**International Co-operation (Minor Head)**			
01	**India's Membership Contribution to Commonwealth Agricultural Bureau**			
010032	Contribution	25.35	60.00	60.00
02	**India's Membership Contribution to Consultative Group on International Agricultural Research**			
020032	Contribution	545.00	549.75	550.00
04	**Asia Pacific Association of Agricultural Research Institutions**			
040032	Contribution	9.00	9.00	10.00
05	**N.A.C.A.**			
050032	Contribution	46.00	48.00	48.00
07	**International Seed Testing Association, Zurich, Switzerland**			
070032	Contribtion	4.25	4.25	5.00
08	**International Society for Horticulture Science, Belgium**			
080032	Contribution	0.40		
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	2400.00	2400.00	2500.00
010035	Grants for creation of Capital Assets	9000.00	5287.00	5500.00
010036	Grants in Aid Salaries	8990.00	11313.00	13000.00
	TOTAL	**49583.00**	**46023.00**	**50560.00**

Notes on Demands For Grants, 2021-2022

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 2019–2020			Budget 2020–2021			Revised 2020–2021			Budget 2021–2022		
		Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
	Gross	*7844.99*	*...*	*7844.99*	*8362.58*	*...*	*8362.58*	*7762.38*	*...*	*7762.38*	*8513.62*	*...*	*8513.62*
	Recoveries	*-321.62*	*...*	*-321.62*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*
	Receipts	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*	*...*
	Net	**7523.37**	**...**	**7523.37**	**8362.58**	**...**	**8362.58**	**7762.38**	**...**	**7762.38**	**8513.62**	**...**	**8513.62**
CENTRE'S EXPENDITURE													
Establishment Expenditure of the Centre													
1. Secretariat		12.20	...	12.20	13.85	...	13.85	13.11	...	13.11	14.05	...	14.05
Central Sector Schemes/Projects													
2. Agricultural Extension		221.15	...	221.15	242.50	...	242.50	237.49	...	237.49	328.00	...	328.00
3. Agricultural Engineering		64.02	...	64.02	70.00	...	70.00	58.55	...	58.55	65.00	...	65.00
Management of Natural Resources													
4. Natural Resource Management Institutes including Agro Forestry Research		158.83	...	158.83	174.00	...	174.00	173.38	...	173.38	195.00	...	195.00
5. Climate Resilient Agriculture Initiative		46.00	...	46.00	52.00	...	52.00	49.83	...	49.83	55.00	...	55.00
Total-Management of Natural Resources		**204.83**	**...**	**204.83**	**226.00**	**...**	**226.00**	**223.21**	**...**	**223.21**	**250.00**	**...**	**250.00**
Crop Sciences													
6. Crop Science		635.00	...	635.00	715.50	...	715.50	612.25	...	612.25	708.00	...	708.00
7. Horticultural Science		173.61	...	173.61	194.00	...	194.00	181.72	...	181.72	212.00	...	212.00
8. National Agricultural Science Fund		50.00	...	50.00	55.00	...	55.00	42.00	...	42.00	48.00	...	48.00
Total-Crop Science		**858.61**	**...**	**858.61**	**964.50**	**...**	**964.50**	**835.97**	**...**	**835.97**	**968.00**	**...**	**968.00**
Animal Sciences													
9. Animal Science		310.00	...	310.00	330.00	...	330.00	274.12	...	274.12	302.00	...	302.00
10. Fisheries Science		142.39	...	142.39	156.00	...	156.00	145.76	...	145.76	160.00	...	160.00
Total -Animal Science		**452.39**	**...**	**452.39**	**964.50**	**...**	**964.50**	**835.97**	**...**	**835.97**	**968.00**	**...**	**968.00**

(Contd...)

Contd...

Schemes	Actual 2019–2020			Budget 2020–2021			Revised 2020–2021			Budget 2021–2022		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Agricultural Education												
11. Agricultural Universities and Institutions	450.00	...	450.00	480.00	...	480.00	319.90	...	319.90	355.00	...	355.00
12. Economic Statistics and Management	29.76	...	29.76	30.00	...	30.00	30.00	...	30.00	33.00	...	33.00
13. National Agricultural Higher Education Project	207.85	...	207.85	230.00	...	230.00	180.00	...	180.00	225.00	...	225.00
Total-Agricultural Education	**687.61**	**...**	**687.61**	**740.00**	**...**	**740.00**	**629.90**	**...**	**629.90**	**613.00**	**...**	**613.00**
Total-Central Sector Schemes/Projects	**2488.61**	**...**	**2488.61**	**2729.00**	**...**	**2729.00**	**2305.00**	**...**	**2305.00**	**2686.00**	**...**	**2686.00**
Other Central Sector Expenditure												
Autonomous Bodies												
14. ICAR Headquarters	4868.80	...	4868.80	5137.75	...	5137.75	4997.15	...	4997.15	5322.02	...	5322.02
15. Central Agricultural Universities	459.18	...	459.18	459.80	...	459.80	428.52	...	428.52	470.95	...	470.95
16. National Academy of Agricultural Sciences	1.36	...	1.36	1.60	...	1.60	1.60	...	1.60	1.60	...	1.60
17. Agricultural Scientists Recruitment Board	14.84	...	14.84	20.58	...	20.58	17.00	...	17.00	19.00	...	19.00
Total -Autonomous Bodies	**5344.18**	**...**	**5344.18**	**5619.73**	**...**	**5619.73**	**5444.27**	**...**	**5444.27**	**5813.57**	**...**	**5813.57**
Others												
18. Actual Recoveries	-321.62	...	-21.62	...	...	...	...	...	...	...	...	...
Total -Other Central Sector Expenditure	**5022.56**	**...**	**5022.56**	**5619.73**	**...**	**5619.73**	**5444.27**	**...**	**5444.27**	**5813.57**	**...**	**5813.57**
Grand Total	**7523.37**	**...**	**7523.37**	**8362.58**	**...**	**8362.58**	**7762.38**	**...**	**7762.38**	**8513.62**	**...**	**8513.62**
Developmental Heads												
Economic Services												
1. Agricultural Research and Education	7517.30	...	7517.30	7820.10	...	7820.10	7258.34	...	7258.34	7857.70	...	7857.70
2. Secretariat-Economic Services	6.07	...	6.07	7.55	...	7.55	6.40	...	6.40	7.32	...	7.32
Total -Economic Services	**7523.37**	**...**	**7523.37**	**7827.65**	**...**	**7827.65**	**7264.74**	**...**	**7264.74**	**7865.02**	**...**	**7865.02**
Others												
3. North Eastern Areas	...	...	...	534.93	...	534.93	497.64	...	497.64	648.60	...	648.60
Total-Others	**...**	**...**	**...**	**534.93**	**...**	**534.93**	**497.64**	**...**	**497.64**	**648.60**	**...**	**648.60**
Grand Total	**7523.37**	**...**	**7523.37**	**8362.58**	**...**	**8362.58**	**7762.38**	**...**	**7762.38**	**8513.62**	**...**	**8513.62**

1. **Secretariat—**The provision is for the expenditure on salary of DARE staff.
2. **Agricultural Extension**—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 and planting materials and testing of soil and water samples.
3. **Agricultural Engineering—**The provision is for research, development and refinement of farm equipment, process and value addition protocols.
4. **Natural Resource Management Institutes including Agro-Forestry Research—**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. **Climate Resilient Agriculture Initiative—**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. **Crop Science—**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. **Horticultural Science—**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. **National Agricultural Science Fund—**Supports basic and strategic research in agriculture to address the prioritized research problems.
9. **Animal Sciences—**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. **Fisheries Science—**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. **Agricultural Universities and institutions—**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. **Economics, Statistics and Management—**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. **National Agricultural Higher Education (EAP)**—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, 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 on par with global agricultural standards.
14. **ICAR Headquarter—**provision is primarily for the salaries, pensions and expenses on administrative and logistic support to different schemes under ICAR in order to implement them efficiently.
15. **Central Agricultural Universities—**The provision is to strengthen the regional education, research and extension capabilities based on local agro-climatic situation.
16. **National Academy of Agricultural Sciences—**The provision is to provide a forum to Agricultural Scientists to deliberate on important issues of agricultural research, education and extension and present views of the scientific community as policy inputs to planners, decision/opinion makers at various levels.
17. **Agricultural Scientists Recruitment Board—**The provisions are for the separate autonomous 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.

2. 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.

3. 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.

4. The Chief Controller of Accounts, Ministry of Agriculture and Farmers Welfare performs his duties with the assistance of Controller/ Assistant Controller of Accounts, three Pr. Accounts Officers at HQ and 10 Pay and Accounts Offices. Four Pay and Accounts Offices are located in Delhi/NCR, two in Mumbai, One each in 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.

5. 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.

6. As per provisions contained in Civil Accounts Manual,

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 useful financial reporting.

7. 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 CGA etc.
   (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.
8. 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-heads of the 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 & 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.
9. 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.
10. The verification and authorization of pensionary entitlement of officers and staff members is done by the Pay & Accounts Offices on the basis of service particulars and 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.

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 an aid 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 Ministry under the Chairmanship of AS & FA (Agriculture & Farmers Welfare) with the approval of Secretary (Agriculture and Farmers Welfare) and terms of reference of Internal Audit Committee has been defined in O/o CCA OM No. Agri/IAW/Audit Committee DAC)/2020–21/158–195 dated 08.09.2020.

(d) During the financial year 2021–22, 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 31.12.2021 are given below:

Banking Arrangements

State Bank of India is the accredited bank for PAOs and its field offices in the Ministry of Agriculture & farmers Welfare. e-payments processed by the PAOs/CDDOs are settled through CMP, SBI, Hyderabad in favor 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 10 (Ten) Pay & Accounts Offices. Four PAOs are located in Delhi/NCR, two in Mumbai, One each in Chennai, Cochin, Kolkata and Nagpur. All payments pertaining to the Department/Ministry are made through PAOs/CDDOs attached with respective PAOs. Drawing and Disbursing Officers present their claims/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 on e-payment

The e-payment system in all Pay & Accounts Offices of Ministry of Agriculture & 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.

Department	Outstanding paras upto 31.03.2021	Paras raised from 01.04.2021 to 30.06.2021	Paras dropped from 01.04.2021 to 30.06.2021	Total outstanding Paras as on 30.06.2021
DARE	12	NIL	NIL	12
Total	12	NIL	NIL	12

Department	Outstanding paras upto 30.06.2021	Paras raised from 01.07.2021 to 30.09.2021	Paras dropped from 01.04.2021 to 30.09.2021	Total outstanding Paras as on 30.09.2021
DARE	12	NIL	NIL	12
Total	12	NIL	NIL	12

Department	Outstanding paras upto 30.09.2021	Paras raised from 01.10.2021 to 31.12.2021	Paras dropped from 01.10.2021 to 31.12.2021	Total outstanding Paras as on 31.12.2021
DARE	12	NIL	12	NIL
Total	12	NIL	12	NIL

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 e-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.

2. 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 mile utilization.
3. 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 universalise 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 PFMS EAT module
(c) Accounting Module for registered agencies
(d) Treasury Interface
(e) PFMS-PRI fund flow and utilization interface
(f) Mechanism for State Governments towards fund tracking for State schemes
(g) Monitoring of 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 & Cooperative Banks

Modules to Implement Enhanced mandate

1. PAO Computerization-Online payments, receipts and accounting of Govt. of India
(a) Programme Division module
(b) DDO module
(c) PAO module
(d) Pension module
(e) GPF & 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) CBDT PAN 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. NREGASoft, AwasSoft
- 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 software application
- Deployment and training of trainers
- Continuous support for implementation

At present, all ten (10) Pay & Accounts Offices of M/o Agriculture farmer welfare, four (4) PAOs are located in Delhi/NCR, Two in Mumbai, One each in 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 & Disbursing Offices of Ministry of Agriculture & 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 & 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 & Farmer welfare since inception in FY 2019-20.
- The collection of Non-Tax revenue of the Department of Agricultural Research and Education in the current Financial Year 2021-22 up to 31.12.2021 is Rs.11.00 Crores, and of it Rs.06.31 Crores have been collected through Bharat Kosh on NTR e-Portal.
- 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 & Education, the TSA is implemented in the following:

- Indian Council of Agricultural Research (ICAR)
- Central Agriculture University, Imphal

The details of the Budgetary Provision & Expenditure their against is reflected below:

TSA Figures as on 31-12-2021

(Rs. in Crore)

Name of ABs	Budget Estimate	Releases	% of Releases
ICAR 8008.02	6006.02	75%	
Central Agriculture University, Imphal	210.00	105.00	50%

New Developments in the Ministry

I. Enforcement of enhanced security layers in online payment process in Public Financial Management System (PFMS)

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) Implementation of OTP based log in system on PFMS in phased manner.

❑

APPENDIX 3

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 & 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 &
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 & Programme Implementation and
MoS of Corporate Affairs,
Government of India, Room No. 132,
NITI Aayog, New Delhi 110 001

5. Dr Jitendra Singh — Ex-officio
Minister of State (IC) for Science & 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 & 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 &
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 — Ex-officio
Minister of State for Fisheries,
Animal Husbandry and Dairying
Government of India
Krishi Bhavan, New Delhi 110 001

4(*vi*) *Ministers in the States in-charge of Agriculture/ Horticulture/Animal Husbandry/Fisheries.*

ANDHRA PRADESH

12. Shri Kurasala Kannababu — 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 & 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 & Fisheries,
Government of Arunachal Pradesh
CM Secretariat, Itanagar,
Arunachal Pradesh 791 111

ASSAM

15. Shri Atul Bora — Ex-officio
Minister for Agriculture & Horticulture & Animal
Husbandry
Government of Assam,
Assam (Civil) Secretariat, Dispur,
Guwahati, Assam 781 006

16. Shri Parimal Suklabaiya — Ex-officio
Minister of Fisheries,
Government of Assam,
Assam (Civil) Secretariat, Dispur,
Guwahati, Assam 781 006

BIHAR

17. Shri Amrendra Pratap Singh — Ex-officio
Minister for Agriculture
Government of Bihar,
Vikas Bhavan, New Secretariat
Bailey Road, Patna, Bihar 800 015

18. Shri Mukesh Sahani — Ex-officio
Minister for Animal Husbandry & Fisheries
Government of Bihar
Vikas Bhavan, New Secretariat
Bailey Road, Patna, Bihar 800 015

CHATTISGARH

19. Shri Ravindra Choubey — Ex-officio
Minister of Agriculture, Animal Husbandry & Fisheries
Government of Chhattisgarh
Mahanadi Bhawan, Mantralaya
Naya Raipur, Chattisgarh 492 002

DELHI

20. Shri Gopal Rai — Ex-officio
Minister for Development
Delhi Secretariat, I.P. Estate,
New Delhi 110 002

GOA

21. Shri Chandrakant Kavalekar — Ex-officio
Minister of Agriculture
Government of Goa, Secretariat
Porvorim, Goa 403 521

22. Shri Pramod Sawant — Ex-officio
Hon'ble Chief Minister and holding the charge of Ministry of Animal husbandry
Government of Goa, Secretariat
Porvorim, Goa 403 521

23. Shri Filipe Neri Rodrigues — Ex-officio
Minister of Fisheries
Government of Goa, Secretariat
Porvorim, Goa 403 521

GUJARAT

24. Shri Raghavjibhai Hansrajbhai Patel — Ex-officio
Minister for Agriculture & Animal Husbandry,
Government of Gujarat
Swarnim Sankul-I, New Sachivalaya
Gandhinagar, Gujarat 382 010

25. Shri Jitubhai Harjibhai Chaudhari — Ex-officio
Minister of State (IC) for Fisheries
Government of Gujarat
Swarnim Sankul-I, New Sachivalaya
Gandhinagar, Gujarat 382 010

HARYANA

26. Shri Jai Prakash Dalal — Ex-officio
Minister for Agriculture and Farmers Welfare, Fisheries & Animal Husbandry,
Government of Haryana
Haryana Civil Secretariat
Chandigarh, Haryana

HIMACHAL PRADESH

27. Shri Virender Kanwar — Ex-officio
Minister for Agriculture, Animal Husbandry and Fisheries, Government of Himachal Pradesh,
H.P. Secretariat,
Shimla, Himachal Pradesh 171 002

28. Shri Mahender Singh — Ex-officio
Minister for Horticulture
Government of Himachal Pradesh
H.P. Secretariat, Shimla,
Himachal Pradesh 171 002

JHARKHAND

29. Shri Badal Patralekh — Ex-officio
Minister of Agriculture, Animal Husbandry,
Government of Jharkhand, Project Building HEC,
Dhurva, Ranchi, Jharkhand 834 002

KARNATAKA

30. Shri B.C. Patil — Ex-officio
Minister for Agriculture
Government of Karnataka
Vidhan Soudha, Bengaluru, Karnataka 560 001

31. Shri N. Muniratna — Ex-officio
Minister for Horticulture,
Government of Karnataka,
Vidhan Soudha, Bengaluru, Karnataka 560 001

32. Shri Prabhu Chauhan — Ex-officio
Minister of Animal Husbandry
Government of Karnataka
Vikasa Soudha, Vidhan Soudha,
Bengaluru, Karnataka 560 001

33. Shri S. Angara — Ex-officio
Minister of Fisheries
Government of Karnataka
Vikasa Soudha, Vidhan Soudha,
Bengaluru, Karnataka 560 001

KERALA

34. Shri Sri P. Prasad — Ex-officio
Minister for Agriculture
Government of Kerala
Government Secretariat Annexe
Thiruvananthapuram, Kerala 695 001

35. Shri J. Chinchu Rani — Ex-officio
Minister for Animal Husbandry
Government of Kerala
Government Secretariat Annexe
Thiruvananthapuram, Kerala 695 001

36. Shri Saji Cherian — Ex-officio
Minister for Fisheries
Government of Kerala
Government Secretariat Annexe
Thiruvananthapuram, Kerala 695 001

MADHYA PRADESH

37. Shri Kamal Patel — Ex-officio
Minister of Agriculture Development
Government of Madhya Pradesh
Vallabh Bhavan, Bhopal
Madhya Pradesh 423 006

38. Shri Prem Singh Patel — Ex-officio
Minister of Animal Husbandry
Government of Madhya Pradesh
Vallabh Bhavan, Bhopal
Madhya Pradesh 423 006

39. Shri Tulsi Silawat — Ex-officio
Minister of Fisheries Welfare and Fisheries Development,
Government of Madhya Pradesh
Vallabh Bhavan, Bhopal
Madhya Pradesh 423 006

40. Shri Bharat Singh Kushwaha (MoS independent charge) Minister of State for Horticulture Government of Madhya Pradesh Vallabh Bhavan, Bhopal Madhya Pradesh 423 006 — Ex-officio

MAHARASHTRA

41. Shri Dadaji Dagadu Bhuse Minister for Agriculture Government of Maharashtra Mantralaya, Mumbai Maharashtra 400 032 — Ex-officio

42. Shri Sandipanrao Bhumre Minister for Horticulture Government of Maharashtra Mantralaya, Mumbai Maharashtra 400 032 — Ex-officio

43. Shri Sunil Chattrapal Kedar Minister for Animal Husbandry Government of Maharashtra Mantralaya, Mumbai Maharashtra 400 032 — Ex-officio

44. Shri Aslam Shaikh Minister for Fisheries Government of Maharashtra Mantralaya, Mumbai Maharashtra 400 032 — Ex-officio

MANIPUR

45. Shri Oinam Lukhoi Singh Minister for Agriculture & Animal Husbandry Government of Manipur Secretariat, Imphal, Manipur 795 001 — Ex-officio

46. Shri Shorokhaibam Rajen Minister for Fisheries Government of Manipur, Secretariat Imphal, Manipur 795 001 — Ex-officio

MEGHALAYA

47. Shri Banteidor Lyngdoh Ministry of Agriculture & Horticulture Government of Meghalaya, Meghalaya Secretariat (C) Shillong, Meghalaya 793 001 — Ex-officio

48. Shri Sanbor Shullai Minister for Animal Husbandry Government of Meghalaya Meghalaya Secretariat (C) Shillong, Meghalaya 793 001 — Ex-officio

49. Shri Sniawbhalang Dhar Minister for Fisheries Government of Meghalaya Meghalaya Secretariat (C) Shillong, Meghalaya 793 001 — Ex-officio

MIZORAM

50. Shri Pu Zoramthanga Hon'ble Chief Minister & holding the charge of Ministry of Horticulture Government of Mizoram Aizwal, Mizoram 796 001 — Ex-officio

51. Shri Pu Tawnluia Ministry for Animal Husbandry Government of Mizoram Aizwal, Mizoram 796 001 — Ex-officio

52. Shri Pu C. Lalrinsanga Minister for Agriculture Government of Mizoram Aizwal, Mizoram 796 001 — Ex-officio

53. Pu K. Lalrinliana Minister of State for Fisheries, Government of Mizoram, Aizwal, Mizoram 796 001 — Ex-officio

NAGALAND

54. Shri Neiphiu Rio Chief Minister holding the charge of Ministry of Horticulture, Animal husbandry & Fisheries Government of Nagaland Civil Secretariat Complex Kohima, Nagaland 797 004 — Ex-officio

55. Shri G. Kaito Aye Minister of Agriculture Government of Nagaland Civil Secretariat Complex Kohima, Nagaland 797 004 — Ex-officio

ODISHA

56. Shri Arun Kumar Sahoo Minister for Agriculture, Fisheries & Animal Resource Development Government of Odisha Odisha Secretariat Bhubaneswar, Odisha 751 001 — Ex-officio

PUNJAB

57. Shri Randeep Singh Nabha Minister of Agriculture Government of Punjab Punjab Civil Secretariat Chandigarh, Punjab — Ex-officio

58. Shri Rana Gurjeet Singh Minister of Horticulture Government of Punjab Punjab Civil Secretariat Chandigarh, Punjab — Ex-officio

59. Shri Tript Rajinder Singh Bajwa Ministry for Animal Husbandry & Fisheries Government of Punjab Punjab Civil Secretariat Chandigarh, Punjab — Ex-officio

PUDUCHERRY

60. Shri C. Djeacoumar Minister of Agriculture & Animal Husbandry Government of Puducherry Puducherry 605 001 — Ex-officio

61. Shri K. Lakshminarayanan Minister for Fisheries Government of Puducherry Puducherry 605 001 — Ex-officio

RAJASTHAN

62. Shri Lal Chand Kataria Minister for Agriculture, Animal Husbandry & Fisheries Government of Rajasthan Rajasthan Secretariat, Mantralaya Bhawan, Jaipur, Rajasthan 302 005 — Ex-officio

SIKKIM

63. Shri Lok Nath Sharma — Ex-officio
Minister for Agriculture Development & Horticulture, Animal Husbandry,
Government of Sikkim, New Secretariat,
Development Area, Gangtok, Sikkim 737 101

TAMIL NADU

64. Shri Thiru M.R.K. Panneerselvam — Ex-officio
Minister for Agriculture & Horticulture
Government of Tamil Nadu
Chennai, Tamil Nadu 600 009

65. Shri Thiru Anitha R. Radhakrishnan — Ex-officio
Minister for Fisheries & Animal Husbandry
Government of Tamil Nadu,
Chennai, Tamil Nadu 600 009

TELANGANA

66. Shri Singireddy Niranjan Reddy — Ex-officio
Minister of Agriculture
Government of Telangana
Haka Bhawan, 2nd Floor, Nampally
Telangana Secretariat
Hyderabad, Telangana 500 004

67. Shri Talasani Srinivas Yadav — Ex-officio
Minister of Animal husbandry & Fisheries,
Government of Telangana, Room No. 261,
D-Block, Telangana Secretariat,
Hyderabad, Telangana 500 022

TRIPURA

68. Shri Pranajit Singha Roy — Ex-officio
Minister for Agriculture
Government of Tripura
Civil Secretariat
Agartala, Tripura 799 001

69. Shri Mevar Kumar Jamatia — Ex-officio
Minister for Fisheries
Government of Tripura, Civil Secretariat
Agartala, Tripura 799 010

70. Smt. Bhagaban Ch. Das — Ex-officio
Minister for Animal Resource Development
Government of Tripura, Civil Secretariat,
Agartala, Tripura 799 001

UTTARAKHAND

71. Shri Subodh Uniyal — Ex-officio
Minister for Agriculture & Horticulture
Government of Uttarakhand
Uttarakhand Vidhan Sabha Bhawan
Dehradun, Uttarakhand

72. Smt. Rekha Arya — Ex-officio
Minister for Animal Husbandry & Fisheries
Government of Uttarakhand
Uttarakhand Vidhan Sabha Bhawan
Dehradun, Uttarakhand

UTTAR PRADESH

73. Shri Surya Pratap Shahi — Ex-officio
Minister of Agriculture
Government of Uttar Pradesh
UP Civil Secretariat, Lucknow, Uttar Pradesh

74. Shri Laxmi Narayan Chaudhary — Ex-officio
Minister of Animal Husbandry & Fisheries
Government of Uttar Pradesh
UP Civil Secretariat
Lucknow, Uttar Pradesh

75. Shri Shriram Chauhan — 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
Kolkata, West Bengal 711 102

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, West Bengal 700 106

78. Shri Akhil Giri — Ex-officio
Minister of State for Fisheries
Government of West Bengal
Benfish Tower, 8th Floor, GN Block,
Salt Lake, Sector-V
Kolkata, West Bengal 700 091

79. Shri Subrata Saha — Ex-officio
Minister for State for Horticulture
Government of West Bengal
Mayukh Bhavan, 2nd Floor, Sector-I,
Salt Lake, Kolkata, West Bengal 700 091

4(vii) Member, NITI Ayog, In-charge of Agriculture

80. Dr 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

82. VACANT

83. VACANT

84. VACANT

85. VACANT

86. VACANT

4(*ix*) *Director-General, Indian Council of Agricultural Research*

87. Dr T. Mohapatra — Ex-officio
Secretary, DARE & DG, ICAR
Krishi Bhavan, New Delhi 110 001

4(*x*) *All Secretaries in the Ministry of Agriculture and Farmers Welfare*

88. Shri Sanjay Agarwal — Ex-officio
Secretary, Deptt. of Agriculture &
Farmers Welfare, Ministry of Agriculture &
Farmers Welfare, Krishi Bhavan,
New Delhi 110 001

4(*xi*) *All Secretaries in the Ministry of Fisheries, Animal Husbandry and Dairying*

89. Shri Jatindra Nath Swain, Ex-officio
Secretary, Department of Fisheries
Ministry of Fisheries, Animal Husbandry and Dairying,
Government of India, Krishi Bhavan,
New Delhi 110 001

90. Shri Atul Chaturvedi Ex-officio
Secretary, Department of Animal Husbandry and Dairying, Ministry of Fisheries,
Animal Husbandry and Dairying,
Government of India, Krishi Bhavan,
New Delhi 110 001

4(*xii*) *CEO, NITI Ayog*

91. Shri Amitabh Kant Ex-officio
CEO, Niti Ayog, Yojana Bhavan,
Sansad Marg, New Delhi 110 001

4(*xiii*) *Secretary, Department of Biotechnology.*

92. Dr Rajesh S. Gokhale Ex-officio
Secretary
Department of Biotechnology
Block 2, 7th Floor, CGO Complex
Lodhi Road, New Delhi 110 003

4(*xiv*) *Director-General, Council of Scientific and Industrial Research*

93. Dr Shekhar C. Mande 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. Shri K. Sanjay Murthy 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. Shri Kamlesh Nilkanth Vyas Ex-officio
Chairman, Atomic Energy Commission
Department of Atomic Energy
Anushakti Bhavan
Chhatrapati Shivaji Maharaj Marg
Mumbai, Maharashtra 400 001

4(xvii) Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India.

96. Sh. Rajeev Ranjan Ex-officio
Additional Secretary (Expenditure)
Department of Expenditure
Ministry of Finance, North Block, New Delhi 110 001

Alternative member for Ministry of Finance - AS & FA (DARE/ICAR)

97. Shri Sanjiv Kumar Ex-officio
AS & FA (DARE/ICAR), Krishi Bhawan
New Delhi 110 001

4(*xviii*) *Five Vice-Chancellors of Agricultural Universities, nominated by the President*

98. Prof S.K. Rao, 17.05.2023/
Vice Chancellor, VC Term-25/10/2022
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
Race Course Road,
Gwalior, Madhya Pradesh 474 002

99. Dr Parvinder Kaushal 17.05.2023/
Vice Chancellor, VC Term-31/03/2022
Dr Y S Parmar University of Horticulture & Forestry
Solan, Nauni, Himachal Pradesh 173 230

100. Prof G.K. Singh 17.05.2023/
Vice Chancellor VC Term-01/03/2022
UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa
Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan
Mathura, Uttar Pradesh 281 001

101. Dr Anupam Mishra 29.12.2023/
Vice Chancellor, VC Term-01/03/2022
Central Agricultural University,
Imphal, P. O. Box No. 23,
Imphal, Manipur 795 004

102. VACANT

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 S.K. Malhotra Ex-officio
Agriculture Commissioner
Dept. of Agriculture & Farmers Welfare,
Ministry of Agriculture & Farmers Welfare
Krishi Bhavan, New Delhi 110 001

104. Dr S.K. Malhotra (Acting Charge) Ex-officio
Horticulture Commissioner
Dept. of Agriculture & Farmers Welfare
Ministry of Agriculture & Farmers Welfare
Krishi Bhavan, New Delhi 110 001

105. Dr Praveen Malik Ex-officio
Animal Husbandry Commissioner
Dept. of Animal Husbandry & Dairying
Ministry of Fisheries, Animal Husbandry & Dairying
Krishi Bhavan, New Delhi 110 001

106. Dr I.A. Siddiqui (Acting Charge) Ex-officio
Fisheries Development Commissioner
Department of Fisheries
Ministry of Fisheries, Animal Husbandry & Dairying
Krishi Bhavan, New Delhi 110 001

107. Dr Suneesh Buxy Ex-officio
Inspector General of Forests (NAEB)
Ministry of Environment & Forests
Paryavaran Bhawan, B-Block
CGO Complex, Lodi Road
New Delhi 110 003

4(*xx*) *Fifteen scientists from within and outside the Council including one representative from the Indian Council of Medical Research*

108. Dr G. Kumaraswamy 11.11.2024
H. No. 7-42/25, Saraswathi Colony
Street no. 4A, Bapuji Nagar, Nacharam
Hyderabad, Telangana 500 076

109. Dr A. Veerabhadra Rao 11.11.2024
12-13-483/39/1, Tarnaka
Street No 14, Lane 6,
Hyderabad, Telangana 500 017

110. Dr Bagwan Naimoddin 11.11.2024
Dr. N.B. Bagwan, 98-H, Sanjari Park-2&3,
Nr. GEB Colony, Pethapur
Gandhinagar, Gujarat 382 610

111. Dr Swadhinta Krishna 11.11.2024
V-5 Osho Universe, Vinayak Puram,
Sector-12, Vikas Nagar
Lucknow, Uttar Pradesh 226 022

112. Dr Rajendra Prasad 11.11.2024
Associate Professor
Department of Horticulture
Kulbhaskar Ashram P.G. College
4/4 C Muir Road Near Anand Hospital
Prayagraj, Uttar Pradesh 211 002

113. Dr Nitai Charan Das 11.11.2024
Department of Soil and Water Conservation
Bidhan Chandra Krishi Viswavidyalaya
Mohanpur, West Bengal 741 252

114. Shri Dinesh Patil 11.11.2024
Parth–Granth, Ward no. 42
Subhash Nagar, Durg
Chhattisgarh 491 001

115. Dr Yogesh A. Murkute 11.11.2024
PG Department of Ceology
RTM Nagpur University
Larv College Square
Nagpur, Maharashtra 440 001

116. Dr Koushik Majumdar 11.11.2024
Centre for Bamboo Cultivation and Resources Utilization (BCRU)
Department of Botany, Tripura University
West Tripura, Suryamaninagar, Tripura 799 022

117. Vacant

118. Vacant

119. Vacant

120. Vacant

121. Vacant

Representative from the Indian Council of Medical Research

122. Dr Samiran Panda 07.07.2024
Scientist-G & Head
Epidemiology and Communicable Diseases (ECD)
ICMR Headquarters,
Ansari Nagar, New Delhi 110 029

4(*xxi*) *Three representatives of commerce and industry, nominated by the President*

123. Shri Rajendra Prasad Gupta 07.03.2022
Harsidhi, East Champaran
Bihar 845 422

124. Shri Anil Rao 07.03.2022
967, Sector-14
Gurugram, Haryana

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
Shri Komirisetty Sambasiva Rao
4-109, Pedapalakaluru (PO),
Guntur Rural, District
Guntur, Andhra Pradesh 522 005

128. **(Representative of Region- III)** 17.05.2023
Shri Khangembam Nabakumar Singh,
Kumbi Bazar, P.S.-Kumbi, P.O.-Moirang
Bishnupur, District, Manipur 795 133

129. **(Representative of Region- IV)** 17.05.2023
Shri Sanjeev Kumar Yadav
State Vice-President
Bharatiya Janata Party Kisan Morcha
Jajak Toli Nai Sadak Chowk,
Guru Govind Singh Path Chowk,
Patna City, Patna, Bihar 800 008

130. **(Representative of Region- V)** 17.05.2023
Shri Bikramjit Singh Cheema
Ward No. 9, Payal
Ludhiana, Punjab 141 416

131. **(Representative of Region- VI)** 07.09.2023
Shri Jagdish Singh
Village- Raidhana, Teh. Ladnun
Distt. Nagaur, Rajasthan

132. **(Representative of Region-VII)** 17.05.2023
Shri Manoj Bhaikaji Vyavahare
AT/Post - Ashti, Tal. Mohol, Dist.
Solapur, Maharashtra 413 303

133. **(Representative of Region-VIII)** 07.09.2023
Shri Virupaxi G. Revadigar
Basava Medical Stores
Basava Circle, Main Bazar
Bilagi, Tq: Bilagi
Distt Bagalkot, Karnataka 587 116

4 Representatives of Rural Interests

134. Shri Umendra Dutt 21.11.2024
Kheti Virasat Mission
R.V. Shanti Nagar, Jaitu
Distt Faridkot, Punjab 151 202

135. Shri Manoj Bhai Purushottam Solanki — 21.11.2024
Near Thakar Temple
Junawas Gram Panchayat Road
Madhapar (T. Bhuj), Kutch, Gujarat 370 020

136. Shri Ashok Kumar Tekam — 21.11.2024
Doctor's Residence
Opposite District Copp. Bank
Girls College Road, Bhagat Singh Ward
Seoni 480 661

137. Shri Badri Narayan — 21.11.2024
49- Gyatri 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 Manmohan Singh Chauhan, — 17.05.2023/
Director, — Term-31.03.2021/
NDRI, Karnal, Haryana 132 001 — 31.01.2022

139. Dr Ravishankar C.N. — 17.05.2023/
Director — Term-19.08.2021/
Central Institute of Fisheries Technology — 30.04.2025
CIFT Junction, Willingdon Island,
Matsyapuri P.O., Cochin, Kerala 682 029

140. Dr Narendra Pratap Singh — 17.05.2023/
Director — Term-27.01.2021/
Indian Institute of Pulses Research — 31.01.2022
(IIPR)
Kanpur, Uttar Pradesh 208 024

141. Dr Arun Kumar Tomar — 07.12.2023/
Director — Term- 07.10.2025
Central Sheep and Wool Research
Institute (CSWRI)
Avikanagar, Rajasthan 304 501

4(*xxiv*) *Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR*

142. Shri M. Raghunandan Rao — 17.06.2023/
Secretary — Ex-officio
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/
Secretary — Ex-officio
Department of Agriculture,
Animal Husbandry and Co-operatives
Government of Jharkhand
Ground Floor, Nepal House
Doranda, Ranchi, Jharkhand 834 002

144. Dr Arushi Malik — 17.06.2023/
Secretary — Ex-officio
Department of Animal Husbandry,
Fisheries and Gaupalan
Government of Rajasthan
Room No. 5008, Main Building
Government Secretariat
Jaipur, Rajasthan 302 015

145. Shri T.S. Jawahar — 17.06.2023/Ex-officio
Additional Chief Secretary to
Govt of Tamil Nadu
Animal Husbandry, Dairying and
Fisheries Department Secretariat
Chennai, Tamil Nadu 600 009

4(*xxv*) *One representative of Agro and Agro-Processing Industries nominated by President*

146. Shri Kanwal Singh Chauhan — 05.02.2022
Shimla Farm,
Village- Aterna, District Sonipat, Haryana

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, Uttar Pradesh 226 001

4(*xxvii*) *Secretary, Indian Council of Agricultural Research - Member Secretary*

148. Shri Sanjay Garg — Ex-Officio
Addl. Secy. (DARE) & Secy.(ICAR)
Krishi Bhavan
New Delhi 110 001

APPENDIX 4

MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Rule 35(i)
Chairman

1. Dr Trilochan Mohapatra
   Director-General,
   Indian Council of Agricultural Research
   Krishi Bhawan,
   New Delhi 110 001
   23382629, 23386711(O)
   dg.icar@nic.in

Rule 35(ii)
Member, Finance

2. Shri Rajeev Ranjan — Ex-Officio
   Additional Secretary (Expenditure)
   Department of Expenditure,
   Ministry of Finance,
   North Block
   New Delhi 110 001
   23094811 (O), M: 9977930999
   as-expenditure@gov.in

Alternate member-Financial Adviser(DARE/ICAR)

Shri Sanjiv Kumar, — Ex-Officio
Additional Secretary & Financial Advisor
(Food and Public Distribution/ICAR)
Krishi Bhavan
New Delhi 110 001
Phone: (Off.) 91-11-23383880
Fax: 91-11-23389388
asfa-agri@gov.in

Rule 35(iii)
Chief Executive Officer, National Institution for Transforming India (NITI Aayog)

3. Shri Amitabh Kant, — Ex-Officio
   CEO, Niti Ayog,
   Yojana Bhavan,
   Sansad Marg,
   New Delhi 110 001
   23096574(O)
   amitabh.kant@nic.in

Rule 35(iv)
Secretary, Department of Agriculture & Farmers Welfare

4. Shri Sanjay Agarwal — Ex-Officio
   Secretary (A&FW)
   Department of A&FW
   Ministry of Agriculture & Farmers Welfare
   Krishi Bhavan, New Delhi 110 001
   23382651, 23388444 (O)
   secy-agri@nic.in

Rule 35(v)
Secretary, Department of Animal Husbandry & Dairying

5. Shri Atul Chaturvedi — Ex-Officio
   Secretary, Department of Animal Husbandry & Dairying,
   Ministry of Fisheries, Animal Husbandry & Dairying,
   Krishi Bhavan, New Delhi 110 001
   23382608
   secyahd@nic.in

Rule 35(vi)
Secretary, Department of Fisheries

6. Shri Jatindra Nath Swain — Ex-Officio
   Secretary, Department of Fisheries
   Ministry of Fisheries, Animal Husbandry & Dairying
   Krishi Bhavan, New Delhi 110 001
   23381994
   secy-fisheries@gov.in

Rule 35(vii)
Three Scientists (including one management expert who are not employees of ICAR nominated by the President)

7. Dr Samiran Panda — 07.07.2024
   Scientist-G and Head
   Epidemiology and Communicable Diseases (ECD),
   ICMR Headquarters, Ansari Nagar, New Delhi 110 029

8. Dr Bagwan Naimoddin — 11.11.2024
   Dr N.B. Bagwan, 98-H, Sanjari Park-2&3,
   Near GEB Colony, Pethapur
   Gandhinagar, Gujarat 382 610

9. Dr Rajendra Prasad — 11.11.2024
   Associate Professor
   Department of Horticulture
   Kulbhaskar Ashram P.G. College
   4/4 C Muir Road, Near Anand Hospital
   Prayagraj, Uttar Pradesh 211 002

Rule 35 (viii)
Five Vice-Chancellors of Agricultural Universities-nominated by the President)

10. Dr Anupam Mishra — 29.12.2023/
    Vice Chancellor — VC Term-01/03/2022
    Central Agricultural University, Imphal
    P.O. Box No. 23
    Imphal, Manipur 795 004
    Ph. 0385-2415933(O) M:09425151947
    vc@cau.ac.in

11. Prof S.K. Rao — 17.05.2023
    Vice Chancellor, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
    Race Course Road, Gwalior
    Madhya Pradesh 474 002
    Phone: 0751-2970505, 2970502(O)
    vcrvskvvgwl@gmail.com

12. Dr Parvinder Kaushal — 17.05.2023
    Vice Chancellor, Dr Y S Parmar University of Horticulture and Forestry
    Solan, Nauni
    Himachal Pradesh 173 230
    252356 (O), 252357(O), 01792-252363(O),
    vcuhf@yspuniversity.ac.in

13. Dr N. Kumar — 17.05.2023
    Vice Chancellor, Tamil Nadu Agricultural University
    Coimbatore, Tamil Nadu 641 003
    Tel: 422-6611251, 422-2431788, 422-6611307
    vctnau@tnau.ac.in, tpo@tnau.ac.in

14. Prof. G.K. Singh 17.05.2023
Vice Chancellor
UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan
Mathura, Uttar Pradesh 281 001
Phone: 0565-2470199 (O), 2470664, 2470766 (R)
duvasuvc@gmail.com
M: 7248274404
PS- Shri Sushil Pal
M: 9839293028

Rule 35(ix)
Three Members of Parliament nominated by the President (Two from Lok Sabha and one from Rajya Sabha)

15. **Vacant**
16. **Vacant**
17. **Vacant**

Rule 35(x)
Four Farmers/ Representatives of Rural Areas nominated by the President

18. Shri Bikramjit Singh Cheema 17.05.2023
Ward No. 9, Payal,
Ludhiana, Punjab 141 416
9781400008, 9815952808
bikram.cheema73@gmail.com

19. Shri Jagdish Singh 07.09.2023
Village- Raidhana, Teh. Ladnun,
Distt. Nagaur, Rajasthan
9413037473, 9873422473
balbirathore@gmail.com

20. Shri Manoj Bhai Purushottam Solanki 21.11.2024
Near Thakar Temple
Junawas Gram Panchayat Road
Madhapar (T. Bhuj), Kutch, Gujarat 370 020
09825428100, 09879928100
ramkrushnatrust@gmail.com

21. Shri Badri Narayan 21.11.2024
49, Gyatri Nagar-1, Tonk Road, Sanganer,
Jaipur, Rajasthan 302 018
9414048490, +91 6376-809606

Rule 35(xi)
Three Directors of Research Institutes of the Council to be nominated by the President

22. Dr Arun K. Tomar 07.12.2023
Director, ICAR-Central Sheep & Wool Research Institute, Avikanagar (Malpura)
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01437-220137, M: 9828141699, 9760848835
director.cswri@icar.gov.in
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23. Dr Manmohan Singh Chauhan
Director, ICAR-National Dairy Research Institute,
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24. Dr Ravishankar C.N. 17.05.2023
Director
ICAR-Central Institute of Fisheries Technology
CIFT Junction Matsyapuri PO
Cochin, Kerala 682 029
Ph. No.0484-2666880, 2667727, M: 9446474368
director.cift@icar.gov.in
cnrs2000@gmail.com

Rule 35(xii)
Four representatives of State Governments to be nominated zone-wise on a rotational basis by Director General, ICAR

25. Shri M. Raghunandan Rao, IAS 17.06.2023
Secretary, Agriculture Cooperation Department,
Government of Telangana,
Ground Floor, D-Block,
Fathe Maidan, Near Nizam College, Basheer Bagh,
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Telangana 500 001
040-23452269, Fax: 23457086, 040-23452269
secy-agri@telangana.gov.in

26. Dr Aboobacker Siddique 17.06.2023
Secretary, Department of Agriculture
Animal Husbandry and Co-operatives
Government of Jharkhand
Ground Floor, Nepal House,
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jhagriculture@gmail.com

27. Dr Arushi Malik 17.06.2023
Secretary, Department of Animal Husbandry,
Fisheries and Gaupalan
Government of Rajasthan
Room No. 5008, Main Building, Government Secretariat, Jaipur, Rajasthan 302 015
Ph. 01412227422
secy-ah-rj@nic.in

28. Shri T.S Jawahar, IAS 17.06.2023
Additional Chief Secretary to Government of Tamil Nadu
Animal Husbandry, Dairying and Fisheries Department
Secretariat, Chennai, Tamil Nadu 600 009
Ph. 044- 25672937
ahsec@tn.gov.in

Rule 35(xiii)
One representative of Agro and Agro-Processing Industries nominated by President

29. Shri Kanwal Singh Chauhan 05.02.2022
R/o Shimla Farm, Village-Aterna
District Sonipat, Haryana 131 023
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kanwalsingh62@gmail.com

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
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Uttar Pradesh 226 001
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Sushmasinghubaiit@gmail.com
Sushmasinghup.mahilaayog@gmail.com

Rule 35(xv)
Secretary, ICAR-Member Secretary

31. Shri Sanjay Garg
Additional Secretary, DARE & Secretary, ICAR,
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23384450(O)
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APPENDIX 5

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. **Dr Trilochan Mohapatra**
   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 the Government of India
   Department of Agricultural Research and Education

Deputy Directors General
1. Dr A.K. Singh (Agricultural Extension)
2. Dr Joykrushna Jena (Fisheries Science)
3. Dr Anand Kumar Singh (Horticultural Science)
4. Dr S.K. Chaudhari (Natural Resource Management)
5. Dr B.N. Tripathi (Animal Sciences)
6. Dr Tilak Raj Sharma (Crop Sciences)
7. Dr R.C. Agarwal (Agricultural Education) (Acting)
8. Dr S.K. Chaudhari (Agricultural Engineering) (Addl. charge)

Assistant Directors General

Crop Science
1. Dr R.K. Singh (CC; FFC, Additional Charge)
2. Dr Sanjeev Gupta (OP)
3. Dr D.K. Yadava (Seed)
4. Dr S.C. Dubey (PP&B)

Horticultural Science
1. Dr B.K. Pandey, Vegetable Spices & Medicinal Plant (Acting)
2. Dr Vikramaditya Pandey, Fruits & Plantation Crops (Acting)

Natural Resource Management
1. Dr S. Bhaskar (AAF&CC) (Acting)
2. Dr Adlul Islam (S&WM) (Acting)

Agricultural Engineering
1. Dr Kanchan Kumar Singh (FE)
2. Dr S.N. Jha (PE)

Animal Sciences
1. Dr Amrish Kumar Tyagi (AN&P)
2. Dr Vishesh Kumar Saxena (AP&B)
3. Dr Ashok Kumar (AH) (Acting)

Fisheries Science
1. Dr P. Pravin (MF)
2. Dr Bimal Prasanna Mohanty (IF)

Agricultural Extension
1. Dr V.P. Chahal (Acting)
2. Dr Randhir Singh

Agricultural Education
1. Dr (Mrs.) Seema Jaggi, ADG(HRD)
2. Dr P.S. Pandey (EP&HS, Acting; EQA & R, Acting)

Others Units
1. Dr K. Srinivas (IPTM&PME) (Acting)
2. Dr Shiv Prasad Kimothi (Cdn.)
3. Dr A.K. Vyas (HRM)
4. Dr Atmakuri Ramakrishna Rao (PIM)
5. Dr J.P. Mishra (IR, Acting; OSD, PPP; ICT, Acting)

National Agricultural Science Fund (NASF)
1. Dr D.K. Yadava (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 B.K. Pandey
2. Dr Manish Das
3. Dr Vikramaditya Pandey
4. Dr Anup Kumar Bhattacharjee

Natural Resource Management
1. Dr Adlul Islam
2. Dr B.P. Bhatt

Agricultural Education
1. Dr M.K. Agnihotri
2. Dr (Mrs.) Vanita Jain
3. Dr (Mrs.) Nidhi Verma
4. Dr K.P. Tripathi
5. Dr S.K. Sankhyan
6. Dr Rajesh Rana

Fisheries Science
1. Dr Prem Kumar
2. Dr (Mrs.) Yasmeen Basade

Agricultural Engineering
1. Dr Devinder Dhingra (on deputation)
2. Dr Panna Lal Singh
3. Dr Abhay Kumar Thakur

Animal Sciences
1. Dr Rajan Gupta
2. Dr (Mrs.) Jyoti Misri
3. Dr Ashok Kumar

Agricultural Extension
1. Dr P. Adhiguru
2. Dr Keshava
3. Dr Naresh Girdhar

Others Units
1. Dr N.K. Jain (HRM)
2. Dr M. K. Tripathi (PIM)
3. Dr P.K. Katiha (PIM)
4. Dr Basant Kumar Kandpal (PIM)
5. Dr A.S. Mishra (Tech. Cdn.)
6. Dr Sanjeev Panwar (Tech. Cdn.)
7. Dr Shiv Datt (IPTM)
8. Dr (Mrs.) Manju Gerard
9. Dr Ashok Kumar (NASF)
10. Dr S.K. Singh (DKMA)
11. Dr A.K. Mishra (IR)
12. Dr K.P. Singh (e-gov.)
13. Dr P.K. Rout (DG Office)

National Agricultural Higher Education Project (NAHEP)
1. Dr P. Ramasundaram, PS & NC
2. Dr Prabhat Kumar, PS & NC
3. Dr (Mrs) Hema Tripathi, PS & NC

Agricultural Scientists' Recruitment Board
1. Prof. (Dr) A.K. Misra, Chairman
2. Prof. (Dr) A.K. Srivastava, Member
3. Dr P.K. Chakraborty, Member
4. Dr K.K. Singh, Member

Directorate of Knowledge Management in Agriculture
1. Dr S.K. Singh, Project Director (Acting)

APPENDIX 6

ICAR INSTITUTES AND THEIR DIRECTORS

1. Dr Ashok Kumar Singh
Indian Agricultural Research Institute
New Delhi 110 012
2. Dr Triveni Dutt (Acting)
Indian Veterinary Research Institute
Izatnagar-243 122, Uttar Pradesh
3. Dr Manmohan Singh Chauhan
National Dairy Research Institute
Karnal-132 001, Haryana
4. Dr Narottam Prasad Sahu (Acting)
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5. Dr Ch. Srinivasa Rao
National Academy of Agricultural Research
Management, Rajendranagar, Hyderabad-500 030
Andhra Pradesh
6. Dr Himanshu Pathak
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 Vishal Nath,
OSD, IARI, Jharkhand
10. Dr Eaknath B. Chakurkar
Central Island Agricultural Research Institute
Post Box No. 181, Port Blair-744 101
Andaman & Nicobar Islands
11. Dr O.P. Yadav (Acting)
Central Arid Zone Research Institute
Jodhpur-342 003, Rajasthan
12. Dr Champat Raj Mehta
Central Institute of Agricultural Engineering
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Madhya Pradesh
13. Dr Brijesh Dutt Sharma (Acting)
Central Institute of Arid Horticulture
Bikaner-334 006, Rajasthan
14. Dr Y.G. Prasad
Central Institute for Cotton Research
Post Bag No. 2, Shankar Nagar P.O.
Nagpur-440 010, Maharashtra
15. Dr (Mrs) Neelima Garg (Acting)
Central Institute for Sub-tropical Horticulture
Rehmankhera, PO Kakori
Lucknow-227 107, Uttar Pradesh
16. Dr Om Chand Sharma (Acting)
Central Institute of Temperate Horticulture
Old Air Field, Rangreth-190 007, Jammu & Kashmir
17. Dr Nachiket Kotwaliwale
Central Institute of Post-Harvest
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18. Dr Sujata Saxena (Acting)
Central Institute for Research on Cotton Technology
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19. Dr Anita Karun (Acting)
Central Plantation Crops Research Institute
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20. Dr Narendra Kumar Pandey (Acting)
Central Potato Research Institute
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21. Dr Vinod Kumar Singh
Central Research Institute for Dryland Agriculture
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22. Dr Dinesh Babu Shakyawar
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23. Dr (Mrs) Padmini Swain (Acting)
National Rice Research Institute
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24. Dr Parbodh Chander
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25. Dr M Madhu
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26. Dr D. Damodar Reddy
Central Tobacco Research Institute
Rajahmundry-533 105, Andhra Pradesh
27. Dr M N Sheela (Acting)
Central Tuber Crops Research Institute
Sreekariyam, Thiruvananthapuram-695 017,
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28. Dr Parveen Kumar
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Ela, Old Goa, North Goa-403 402, Goa
29. Dr Ujjawal Kumar (Acting)
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ICAR Parisar, P.O. Bihar Veterinary College
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30. Dr Vinay Kumar Mishra
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31. Dr Rajendra Parsad
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32. Dr Amaresh Chandra
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33. Dr B.N.S. Murthy (Acting)
Indian Institute of Horticultural Research
Hessaraghatta Lake Post, Bengaluru-560 089
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34. Dr Shiv Sewak (Acting)
Indian Institute of Pulses Research
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35. Dr Ashok Kumar Patra
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36. Dr (Mrs) J. Rema (Acting)
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37. Dr Ashwini Dutt Pathak
Indian Institute of Sugarcane Research
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38. Dr K.K. Sharma
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39. Dr Tusar Kanti Behera
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Varanasi-221 005, Uttar Pradesh
40. Dr G Hema Prabha (Acting)
Sugarcane Breeding Institute
Coimbatore-641 007, Tamil Nadu
41. Dr Lakshmi Kant (Acting)
Vivekanand Parvatiya Krishi Anusandhan Sansthan
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42. Dr Gouranga Kar
Central Research Institute for Jute & Allied Fibres
Barrackpore, Kolkata-700 120, West Bengal
43. Dr Azad Singh Panwar
Indian Institute of Farming System Research
Modipuram, Meerut-250 110, Uttar Pradesh
44. Dr Sujoy Rakshit
Indian Institute of Maize Research
PAU Campus, Ludhiana-141 004, Punjab
45. Dr Ravi Kumar Mathur (Acting)
Indian Institute of Oil Palm Research
Pedavegi, West Godavari-534 450,
Andhra Pradesh
46. Dr (Mrs) M. Sujatha (Acting)
Indian Institute of Oilseeds Research
Rajendranagar, Hyderabad-500 030, Telangana
47. Dr Raman Meenakshi Sundaram
Indian Institute of Rice Research
Rajendranagar, Hyderabad-500 030, Telangana
48. Dr Gyanendra Pratap Singh
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49. Dr Atma Ram Mishra (Acting)
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Opposite Rail Vihar, Chandersekharpur
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50. Dr Anil Kumar (Acting)
Central Institute for Women in Agriculture
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P.O. Baramunda, Bhubaneswar-751 003, Odisha
51. Dr Ayyandar Arunachalam
Central Agro-Forestry Research Institute
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52. Dr Dilip Kumar Ghosh
Central Citrus Research Institute
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53. Dr Suresh Pal
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70. Dr Vijendra Pal Singh (Acting)
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71. Dr Abhijit Mitra
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APPENDIX 7

NATIONAL BUREAUX AND THEIR DIRECTORS

1. Dr M Nagesh (Acting)
   National Bureau of Agricultural Insect Resources
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2. Dr Anil Kumar Saxena
   National Bureau of Agriculturally Important
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   Bhanjan-275 101,
   Uttar Pradesh

3. Dr Ashok Kumar (Acting)
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4. Dr Brahma Swaroop Dwivedi
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5. Dr Bishnu Prasad Mishra
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6. Dr Kuldeep Kumar Lal
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APPENDIX 8

PROJECT DIRECTORATES, AGRICULTURAL TECHNOLOGY APPLICATION RESEARCH INSTITUTES AND THEIR DIRECTORS

1. Dr Sandip Kumar Bera (Acting)
Directorate of Groundnut Research,
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2. Dr Pramod Kumar Rai
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Sewar, Bharatpur 321 303, Rajasthan

3. Dr Janaki Sharan Mishra
Directorate of Weed Research
Maharajpur, Adhartal
Jabalpur 482 004, Madhya Pradesh

4. Dr Raviprasad (Acting)
Directorate of Cashew Research
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Dakshina Kannada
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5. Dr K. V. Prasad (Acting)
Directorate of Floriculture Research
Pune, Maharashtra

6. Dr Satyajit Roy (Acting)
Directorate of Medicinal & 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 Major Singh
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 R.N. Chatterjee
Directorate of Poultry Research
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Andhra Pradesh

11. Dr Pramod Kumar Pandey
Directorate of Coldwater Fisheries Research
Anusandhan Bhawan, Industrial Area
Bhimtal 263 136, Uttarakhand

12. Dr S.K. Singh (Acting)
Directorate of Knowledge Management in Agriculture,
Krishi Anusandhan Bhavan-I, Pusa,
New Delhi 110 012

Agricultural Technology Application Research Institutes

13. Dr Rajbir Singh (Acting)
Agricultural Technology Application Research Institute
Zone-I, PAU Campus
Ludhiana 141 004, Punjab

14. Dr Subrata Kumar Roy (Acting)
Agricultural Technology Application Research Institute
Zone-II, Bhumi Vihar, Block-GB
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Kolkata 700 097, West Bengal

15. Dr Anil Kumar Tripathi (Acting)
Agricultural Technology Application Research Institute,
Zone-III, TOP, Umroi Road
Barapani 793 103, Meghalaya

16. Dr Atar Singh (Acting)
Agricultural Technology Application Research Institute,
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17. Dr J.V. Prasad (Acting)
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18. Dr S.K. Singh
Agricultural Technology Application Research Institute
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Jodhpur 342 003, Rajasthan

19. Dr Shyam Ranjan Kumar Singh (Acting)
Agricultural Technology Application Research Institute
Zone-VII, JNKVV Campus
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20. Dr V. Venkatasubramanian
Agricultural Technology Application Research Institute
Zone-VIII, ICAR Transfer of Technology Project
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Karnataka

21. Dr Anjani Kumar
Agricultural Technology Application Research Institute
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Patna 801 506, Bihar

22. Dr Lakhan Singh
Agricultural Technology Application Research Institute
College of Agriculture Campus
Shivajinagar Pune 411 005, Maharashtra

23. Dr Anil Kumar Tripathi
Agricultural Technology Application Research Institute
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Guwahati 781 006, Assam

APPENDIX 9

NATIONAL RESEARCH CENTRES AND THEIR DIRECTORS

1. Dr (Mrs) S. Uma
   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 S D Pandey (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 413 006
   Maharashtra

6. Dr S N Saxena (Acting)
   National Research Centre on Seed Spices
   Tabiji, Ajmer 305 206, Rajasthan

7. Dr Artabandhu Sahoo
   National Research Centre on Camel
   Jorbeer, P.B. No. 07
   Bikaner 334 001, Rajasthan

8. Dr Yashpal (Acting)
   National Research Centre for Equines
   Hisar 125 001
   Haryana

9. Dr Sukhadeo Baliram Barbuddhe
   National Research Centre on Meat
   Chengicherla, P.B. No. 19, Uppal PO
   Hyderabad 500 039, Andhra Pradesh

10. Dr Meraj Haider Khan (Acting)
    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. Balaesahib 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 Keshwan and 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, Other Backward Classes and PwD Employees

S.No.	Class of post	Total posts sanctioned	Total employees in position	SC employees		ST employees		OBC employees		PwD employees	
				No.	% to total employees	No.	% to Total employees	No.	% to total employees	No.	% to total employees
1	**Scientist Posts**										
	a Scientist	4451	3752	537	14.31	217	5.78	1053	28.07	28	0.75
	b Senior Scientist	1295	883	59	6.68	16	1.81	112	12.68	0	0.00
	c Principal Scientist	665	242	13	5.37	3	1.24	24	9.92	1	0.41
	d RMP	175	97	1	1.03	0	0.00	5	5.15	0	0.00
	Total	**6586**	**4974**	**610**	**12.26**	**236**	**4.74**	**1194**	**24.00**	**29**	**0.58**
2	**Technical Posts**										
	a Category I	3974	1997	357	17.88	215	10.77	418	20.93	27	1.35
	b Category II	2708	1595	265	16.61	133	8.34	353	22.13	23	1.44
	c Category III	755	268	28	10.45	42	15.67	65	24.25	1	0.37
	Total	**7437**	**3860**	**650**	**16.84**	**390**	**10.10**	**836**	**21.66**	**51**	**1.32**
3	**Administrative Posts**										
	a Category 'A' posts: Director (SD)/ Director/ JD-cum-Registrar/ Dy. Secretary/ Under Secretary/CAOs/ SAOs/AOs/ Director (F)/Comptroller/ CF&AO/ SFAO/F&AO/ LA/ Director(OL)/ DD(OL)/AD(OL)/PPS	597	279	45	16.13	18	6.45	37	13.26	4	1.43
	b Category 'B' posts: AF&AO/AAO/SO/PS/LO/ALA/Assistant/ PA/JAO	3060	1849	317	17.14	143	7.73	233	12.60	39	2.11
	c Category 'C' posts: UDC/Steno/LDC	1251	958	181	18.89	83	8.66	228	23.80	15	1.57
	Total	**4908**	**3086**	**543**	**17.60**	**244**	**7.91**	**498**	**16.14**	**58**	**1.88**
4	**Supporting Skilled Staff**										
	Total	**5536**	**3960**	**1038**	**26.21**	**444**	**11.21**	**744**	**18.79**	**57**	**1.44**

APPENDIX 13

ICAR AWARDS 2020

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award 2020	**Large institute** 1. ICAR-Central Institute of Agricultural Engineering, Bhopal 2. ICAR- Central Inland Fisheries Research Institute, Barrackpore **Small institute** 1. ICAR- National Research Centre for Banana, Tiruchirapally **University** 1. ICAR-Indian Agricultural Research Institute, New Delhi
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2020	**Best AICRP** 1. All India Coordinated Research Project for Dryland Agriculture, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana **Best Centre** 1. AICRPDA Centre, Bengaluru under UAS, Bengaluru
Pandit Deen Dayal Upadhyay Krishi Vigyan Rashtriya Protshahan Puraskar 2020	**First Prize** – KVK, East Champaran, Piprakothi, Bihar **Second Prize** – KVK, Kalaburgi-I, Aland Road, Kalaburgi, Karnataka **Third Prize** – KVK, Dhar, Madhya Pradesh – KVK, Korea, Chhattisgarh
ICAR Norman Borlaug Award 2020	1. **Dr Kajal Chakraborty** Principal Scientist, Marine Biology Division ICAR-Central Marine Fisheries Research Institute, Kochi
ICAR-Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences	**Crop and Horticultural Sciences** 1. **Dr Om Parkash Yadav** Director, Central Arid Zone Research Institute, Jodhpur, Rajasthan 2. **Dr Bijendra Singh** Vice-Chancellor, ANDUAT, Kumarganj, Ayodhya, Uttar Pradesh **Natural Resource Management and Agricultural Engineering** 1. **Dr Arvind Kumar Shukla** Project Coordinator, AICRP on Micro and Secondary Nutrients and Pollutant Elements, ICAR-IISS Bhopal, Madhya Pradesh 2. **Dr Vinod Kumar Singh** Director, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad **Animal and Fisheries Sciences** 1. **Dr Ashok K.Tiwari** Director, ICAR-Central Avian Research Institute Izatnagar, Uttar Pradesh 2. **Dr Basanta Kumar Das** Director, ICAR-Central Inland Fisheries Research Institute Barrackpore, Kolkata, West Bengal **Social Sciences** 1. **Dr Rakesh Chandra Agrawal** DDG, Agricultural Education (Acting) and National Director National Agricultural Higher Education Project, ICAR, New Delhi

AWARDS	AWARDEES
Lal Bahadur Shastri Outstanding Young Scientist Award 2020	**Crop and Horticultural Sciences** 1. **Dr S.L. Krishnamurthy** Senior Scientist, Plant Breeding, Division of Crop Improvement ICAR-Central Soil Salinity Research Institute, Karnal, Haryana **Natural Resource Management & Agricultural Engineering** 1. **Dr Upendra Kumar** Scientist (SS), ICAR-National Rice Research Institute, Cuttack, Odisha **Animal and Fisheries Sciences** 1. **Dr Sonal** Senior Scientist, Veterinary Biotechnology Division ICAR-Indian Veterinary Research Institute [Deemed University] Izatnagar, Uttar Pradesh **Social Sciences** 1. **Dr Prabina Kumar Meher** Scientist, Division of Statistical Genetics ICAR-Indian Agricultural Statistics Research Institute, New Delhi
Panjabrao Deshmukh Outstanding Women Scientist Award 2020	1. **Dr Gurinderjit Randhawa** Head and Principal Scientist, Division of Genomic Resources ICAR-National Bureau of Plant Genetic Resources, New Delhi
Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2020	**Crop Sciences and Horticulture** 1. **Dr Victor Phani** C/o Bimal Bhattacharjee, Private Housing (Opposite Kunja apartment), Rathtala, Chakbhabani PO, PS: Balurghat, Dakshin Dinajpur, West Bengal 733 101 PhD-ICAR-Indian Agricultural Research Institute, New Delhi **Natural Resource Management and Agricultural Engineering** 1. **Dr Brajesh Nare** ICAR-Central Potato Research Station, Jalandhar PhD-Indian Institute of Technology, Kharagpur, West Bengal **Animal Sciences and Fisheries** 1. **Dr Fasina Makkar** Ernakulam, Kerala PhD-ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala 2. **Dr Meeti Punetha** Division of Animal Physiology and Reproduction ICAR-Central Institute for Research on Buffaloes, Hisar, Haryana Ph.D.-ICAR-Indian Veterinary Research Institute Izatnagar, Uttar Pradesh **Social Sciences** 1. **Dr Sayanti Guha Majumdar** Centre for Agricultural Bioinformatics, ICAR-Indian Agricultural Statistics Research Institute, New Delhi PhD- ICAR-Indian Agricultural Research Institute, New Delhi
Nanaji Deshmukh ICAR Award for Outstanding Interdisciplinary Team Research in Agricultural and Allied Sciences 2020	1. **Dr A.K. Nayak** Principal Scientist and Head, Crop Production Division (Team Leader), ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha 2. **Dr Sangita Mohanty (Associate)** Senior Scientist, ICAR-National Rice Research Institute, Bidyadharpur, Cuttack, Odisha 3. **Dr Mohammad Shahid (Associate)** Senior Scientist, ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha

AWARDS	AWARDEES
	4. **Dr Rahul Tripathi (Associate)** Senior Scientist, ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha
	5. **Dr Upendra Kumar (Associate)** Scientist, ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha
	6. **Dr J. Meher (Associate)** Scientist (SG), ICAR-National Rice Research Institute, Bidyadharpur, Cuttack, Odisha
	7. **Dr S.D. Mohapatra (Associate)** Principal Scientist, ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha
	8. **Dr Dibyendu Chatterjee (Associate)** Scientist, ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha
	9. **Dr Anjani Kumar (Associate)** Scientist, ICAR-National Rice Research Institute Bidyadharpur, Cuttack, Odisha
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2020	1. **Dr Thanuku Samuel Samopath Kumar Patro** Principal Scientist and Head, Plant Pathology, ANGRAU Agricultural Research Station Vizianagaram, Andhra Pradesh
	2. **Smt. Yasarapu Sandhya Rani (Associate)** Principal Scientist and Head, Plant Pathology ANGRAU Agricultural Research Station Vizianagaram, Andhra Pradesh
	3. **Smt. Ungata Triveni (Associate)** Scientist, Agronomy ANGRAU Agricultural Research Station Vizianagaram, Andhra Pradesh
	4. **Dr Mantri Murali Venkata Srinivasa Rao (Associate)** Senior Scientist, Agronomy (IFS) ANGRAU Agricultural Research Station Vizianagaram, Andhra Pradesh
	5. **Dr Narasupalli Anuradha (Associate)** Senior Plant Breeding ANGRAU Agricultural Research Station Vizianagaram, Andhra Pradesh
Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2020	1. **Dr Ajay Kumar Sah** Principal Scientist, IISR, Lucknow
	2. **Dr Sanchita Garai** Scientist, Veterinary Extension Division of Dairy Extension NDRI, Karnal
Vasant Rao Naik Award for Research Application in Agriculture 2020	1. **Dr Deepak Hari Ranade (Team Leader)** Former Chief Scientist, SWCE Rajmata Vijayraje Scindia Agricultural University Gwalior, Madhya Pradesh
	2. **Dr Indu Swarup (Associate)** Principal Scientist, Plant Breeding, Rajmata Vijayraje Scindia Agricultural University Gwalior, Madhya Pradesh
	3. **Dr M.P. Jain (Associate)** Former Chief Scientist, Agronomy Rajmata Vijayraje Scindia Agricultural University Gwalior, Madhya Pradesh

AWARDS	AWARDEES
	4. **Er. M.L. Jadav (Associate)** Scientist, SWE, Rajmata Vijayraje Scindia Agricultural University Gwalior, Madhya Pradesh 5. **Dr D.V. Bhagat (Associate)** Senior Scientist, Agronomy, Rajmata Vijayraje Scindia Agricultural University, Gwalior, Madhya Pradesh
Jagjivan Ram Abhinav Kisan Puruskar/ Jagjivan Ram Innovative Farmer Award 2020	1. **Sh Dhirendrakumar Bhanubhai Desai** S/o Sh. Bhanubhai Gordhanbhai Desai, Panetha, Jhaghadiya, Bharuch, Gujarat 2. **Sh Sharana Basappa Patil,** S/o Sh. Peerappa Patil, Halasutanpur, Kalaburgi, Karnataka 3. a) **Sh Hariman Sharma** S/o Late Sh. Daya Ram, Paniyala, Kothi Ghumarwin, Bilaspur, Himachal Pradesh b) **Smt. Manorama Singh** Agarpur, Lalganj, Vaishali, Bihar
N.G. Ranga Farmer Award for Diversified Agriculture 2020	1. **Sh Dipen Kumar Shah** S/o Sh. Mukundbhai Chhotalal Shah Anand, Kunjrao, Gujarat
Haldhar Organic Farmer Award 2020	1. **Sh Bandaru Venkateshwarlu** Narsimhula Gudem, Munagala, Suryapet, Telengana **2. Sh Ratan Lal Daga** Jodhpur, Rajasthan
Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar 2020	**1. Sh Ganga Ram Sepat** Sepat Organic Krishi Farm, Kalkh, Jobner, Phulera, Jaipur **2. Smt. Bandana Kumari** W/o Sh. Kumud Kumar, Merha, Katoria, Banka, Bihar **3. a) Sh Arunbhai Jasmatbhai Patel** Bala Faliya, Karadi, Jalalpore, Navsari, Gujarat **b) Sh Sanjay Kumar** Plauhta, Upper Behli, Sundernagar, Mandi, Himachal Pradesh
ICAR Best Annual Report Award 2020	**Large Institute** **1. ICAR-Central Inland Brackishwater Aquaculture (CIBA)** Chennai, Tamil Nadu **Small Institutes** **1. ICAR-Indian Institute of Maize Research (IIMR)** Ludhiana, Punjab **2. ICAR-Central Institute of Arid Horticulture (CIAH)** Bikaner, Rajasthan

Acronyms

AAP : Acquisition Access Period
ABI : Agri-business Incubation
ACACA : Acetyl Co-A carboxylase type A
ACE : Angiotensin Converting Enzyme
ACPs : Anti-cancer peptides
ACR : Agro climatic region
ADI : Agroecosystem Diversity Index
AEIS : Agriculture Experts Information System
AFK : Age at first kidding
AFS : Age at first service
AFS : Agro-forestry system
AgIn : Agri-Innovate India Limited
AGP : Antibiotic growth promoter
AICRP : All India Coordinated Research Project
AIs : Artificial inseminations
ALS : Alternaria leaf spot
ALV : Avian leucosis virus
ANN : Artificial neural network
APR : Adult plant resistance
ARMS : Agricultural Research Management System
ARYA : Attracting and Retaining Youth in Agriculture
ASF : African Swine Fever
ASV : Alkali spreading value
ATICs : Agricultural Technology Information Centres
ATPs : Annual Training Plans
AUIPS : Agricultural University Implementation Performance Scoreboard
AURS : Agricultural University Ranking System
bAMH : bovine anti-mullerian hormone
BDL : Below the detectable limit
BILS : Balanced incomplete latin square
BLB : Bacterial leaf blight
BMI : Body mass index
BPDRTDb : Black Pepper Drought Transcriptome Database
BPH : Brown plant-hopper
BSIMV : Banana streak IM virus
BSMA : Broad Subject Matter Area
BSMYV : Banana streak MY virus
BSV : Banana streak viruses
BUSCO : Benchmarking Universal Single-Copy Orthologs
CAAST : Centres for Advanced Agricultural Sciences and Technology
CAM : Crassulacean Acid Metabolism
CAUs : Central Agricultural Universities
CCARI : Central Coastal Agricultural Research Institute
CCD : Central composite design
CCYV : Cucurbit chlorotic yellows virus
CFLDs : Cluster Frontline Demonstrations
ChR : Charcoal rot
CIAS : Composite Index of Agricultural Sustainability
CICR : Central Institute of Cotton Research
NEE : Net Ecosystem Exchange
CIWA : Central Institute for Women in Agriculture
CLP : Curvularia leaf spot
CMB : Cassava mealybug
CN : Calcium nitrate
CNG : Compressed natural gas
CNVs : Copy number variations
COI : Cytochrome c oxidase I
CPCs : Clay-polymer composites
CPIAL : Consumer Price Index for Agriculture Labour
CR : Common rust
CSFV : Classical swine fever virus
CSISA : Cereal Systems Initiatives for South Asia
CUs : Central Universities
CVR : Central variable region
CyHV-2 : Cyprinid herpesvirus
CYSDV : Cucurbit yellow stunting disorder virus
DARE : Department of Agricultural Research and Education
DBS : Differential binding sites
DBT : Direct benefit transfer
DCNN : Deep convolution neural networks
ddRAD : Double digest restriction-site associated
DE : Differentially expressed
DEEs : Directorates of Extension Education
DEGs : Differentially expressed genes
DETM : Diploma in Educational Technology Management
DEV : Duck enteritis virus
DGPI : Digital ginning percentage indicator
DKMA : Directorate of Knowledge management in Agriculture
DLD : Desertification/land degradation
DMF : Dimethylformamide
DsMV : Dasheen mosaic virus
DSn : Diagnostic sensitivity

DSp : Diagnostic specificity
DST : Drought and Salt Tolerance
DTMA : Diploma in Technology Management in Agriculture
DUs : Deemed-to-be-Universities
EDPs : Entrepreneur Development Programme
EG : Ethylene glycol
EL : Experiential Learning
Elnet : Elastic neural network
ELS : Extra Long Staple
EnCoV : Maps of Environment covariates
EPE : Ewe productivity efficiency
EPN : Entomo-pathogenic nematodes
ETT : Embryo transfer technology
EZ : Eastern Zone
FAW : Fall armyworm
FCROS : Fold-change rank ordering statistics
FCV : Flue-cured Virginia
FDH : Freeze-dried encapsulated hydolysates
FFB yield : Fresh fruit bunch yield
FPP : Flower per peduncle
FFIs : Functional food ingredients
FLDs : Frontline Demonstrations
FLIs : Farmers led innovations
FOS : Fructose oligosaccharide
FP : Fully Pressed
FRUITS : Farmer Registration and Unified Beneficiary Information System
FSF : Pusa-Farm Sun Fridge
FtGF : Fantail goldfish fin
FTIR : Fourier-transform infrared
FWKGs : Farm Women Knowledge Groups
GHNVD : Goldfish hematopoietic necrosis viral disease
GIFT : Genetically-Improved Farmed Tilapia
GM : Grey-mildew
GOS : Galactose oligosaccharide
GP : Ginning percentage
GP : Gestation period
GPP : Gross Primary Productivity
GRIS : Germplasm Registration Information System
GRMS : Grievance Redressal and Monitoring System
GS : Genomic selection
GSAQ : Gene Set Analysis with QTL
GSBB : Goa State Biodiversity Board
GSQSeq : Gene Set analysis with QTL sequences
HEIs : Higher Education Institutions
HPAI : Highly pathogenic avian influenza
HRM : Human Resource Management
HRMS : Human Resource Management System
HRR : Head-rice recovery
HS : Heat stress
HT : Hydro treatment
HTh : Hydro thermal
HTS : High throughput sequencing
IAP : Inoculation Access Period
IASRI : Indian Agricultural Statistics Research Institute
IBCR : Incremental benefit cost ratio
IBP : Indigenous Breeds Project
ICAR : Indian Council of Agricultural Research
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
IRS-AWiFs : Indian remote sensing satellite images
ISS : Integrated Sample Survey
KC : Khaki Campbell
KISAAN : Krishi Integrated Solution for Agri Apps Navigation
KPIs : Key Performance Indicators
KSHAMTA : Knowledge Systems and Homestead Agriculture Management in Tribal Areas
KVKs : Krishi Vigyan Kendras
LAC : Learning and Assessment Centre
LAMP : Loop-mediated Isothermal Amplification
LCA : Life cycle assessment
LCFAs : Long chain fatty acids
LCNDV : Tomato Leaf Curl New Delhi Virus
LFIA : Lateral flow immuno assay
LFIA : Lateral flow immunochromatography assay
LRMS : Land Record Management System
LSD : Lumpy skin disease
LSDV : Lumpy skin disease viruses
LSIDs : Life Science Identifiers
LTN : Leaf tip necrosis
LTT : Low Tunnel Technologies
M&AP : Medicinal and Aromatic Plants
MARS : Multivariate Adaptive Regression Spline
MBFerns : Multi-Branch Ferns
MCC : Microcrystalline Cellulose
MDP : Management Development Programme
MEITY : Ministry of Electronics and Information Technology
MGMG : Mera Gaon Mera Gaurav
MGNREGS : Mahatma Gandhi National Rural

	Employment Guarantee Scheme
MLB	: Maydis leaf blight
MoA	: Memorandum of Agreement
MOS	: Mannon oligosaccharide
MoU	: Memorandum of Understanding
MPTs	: Multi-purpose trees
MRMR	: Maximum Relevance and Minimum Redundancy
MSI	: Membrane Stability Index
MSSP	: Mega Sheep Seed Project
MUFA	: Monounsaturated fatty acids
NAARM	: National Academy of Agricultural Research Management
NADRES	: National Animal Disease Referral Expert System
NAE	: Niche Area of Excellence
NAEAB	: National Agricultural Education Accreditation Board
NAIMCC	: National Agriculturally Important Microbial Culture Collection
NARES	: National Agricultural Research System
NARI	: Nutri-sensitive Agricultural Resources and Innovations
NARS	: National Agricultural Research System
NASF	: National Agricultural Science Fund
NBAIR	: National Bureau of Agricultural Insect Resources
NC	: Natural cream
NCBI	: National Centre for Biotechnology Information
NDPPC	: Nanaji Deshmukh Plant Phenomics Centre
NDSAP	: National Data Sharing and Accessibility Policy
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
NIL	: Near Isogenic Lines
NINFET	: National Institute of Natural Fibre Engineering and Technology
NNV	: Nervous necrosis virus
NSK	: Neem-seed kernel
NSP	: Non-structural protein
NSPAAD	: National Surveillance Programme for Aquatic Animal Diseases
NWPSI	: Network Project on Sheep Improvement
OGD	: Open Government Data
OPF	: Oro-pharyngeal fluid
PBND	: Peanut bud necrosis disease
PC	: Phenotypic conversion
PFSR	: Post-flowering stalk rot
PGRC	: Plant Germplasm Registration Committee
PMART	: Portable meat production and retailing facility
PP	: Percentage of positivity
PPR	: Peste des petits ruminants
PPV	: Porcine parvovirus
PRRS	: Porcine Reproductive and Respiratory Syndrome
PRSV	: Papaya ring spot virus
PUFA	: Polyunsaturated fatty acids
PuYV	: Pumpkin Yellows Virus
QTL	: Quantitative trait loci
R eco	: Ecosystem Respiration
RAES	: Resilient Agricultural Education System
RAWE	: Rural Awareness Work Experience
RDF	: Recommended dose of fertilizer
RDM	: Rajasthan downy mildew
RG	: Rhamnogalacturonan
RGNNV	: Red-spotted grouper nervous necrosis virus
RILs	: Recombinant inbred lines
RKN	: Root knot nematodes
RPA	: Recombinase polymerase amplification
RSM	: Response surface methodology
RTD	: Rice-tungro disease
RT-PCR	: Reverse transcriptase polymerase chain reaction
RWC	: Relative Water Content
SAM	: Smart aquaculture model
SARATHI	: System of Agri-information Resources Auto-transmission and Technology Hub Interface
SARS-CoV-2	: Severe acute respiratory syndrome coronavirus 2
PCV-2	: Porcine circovirus-2
SASAH	: Situation Assessment Survey of Agricultural Households
SAUs	: State Agricultural Universities
SCC	: Sodium copper chlorophyll
SCSP	: Support under Scheduled Caste Sub Plan
SDGs	: Sustainable Development Goals
SDM	: Sorghum downey mildew
sGnRH	: Salmon gonadotropin-releasing hormone
SHEET	: Social-health-environmental-economic technological
SI	: Self-Incompatible
SIRC	: Structurally incomplete row-column
SMDs	: Subject Matter Division
SMI	: Soil Moisture Indicator
SNP	: Single Nucleotide Polymorphism
SOC	: Soil organic carbon
SOP	: Standard operating protocol
SPC	: Safflower protein concentrate
SPH	: Safflower protein hydrolysate

SPI : Safflower protein isolate
SREBP-1 : Sterol repeat element binding protein 1
SSP : Single super phosphate
SSS : Skilled Support Staff
SVM : Support Vector Machine
SW : Seed Weight
TDC : Technology Demonstration Component
thNIR : Thermal near infrared rays
TL : Truthfully labelled
TLB : Turcicum leaf blight
TMIS : Training Management Information System
TMV : Tobacco mosaic virus
ToLCBV : Tomato Leaf Curl Bangalore Virus
TPC : Total Plate Count
TR-PBIB : Trend free partially balanced incomplete block
TSA : Treasury Single Account
TSP : Tribal Sub-Plan
UMI : Unique Molecular Identifier
UoH : University of Hyderabad
VAMNICOM : Vaikunth Mehta National Institute of Cooperative Management
VNIR : Visible and near infrared
VNN : Viral nervous necrosis
VOC : Variant of concern
VOCs : Volatile organic compounds
VWG : Vital wheat gluten
WCT : West Coast Tall
WFK : Weight at first kidding
WIPO : World Intellectual Property Organization
WUE : Water Use Efficiency
YLD : Yield under stress condition
ZYMV : Zucchini yellow mosaic virus

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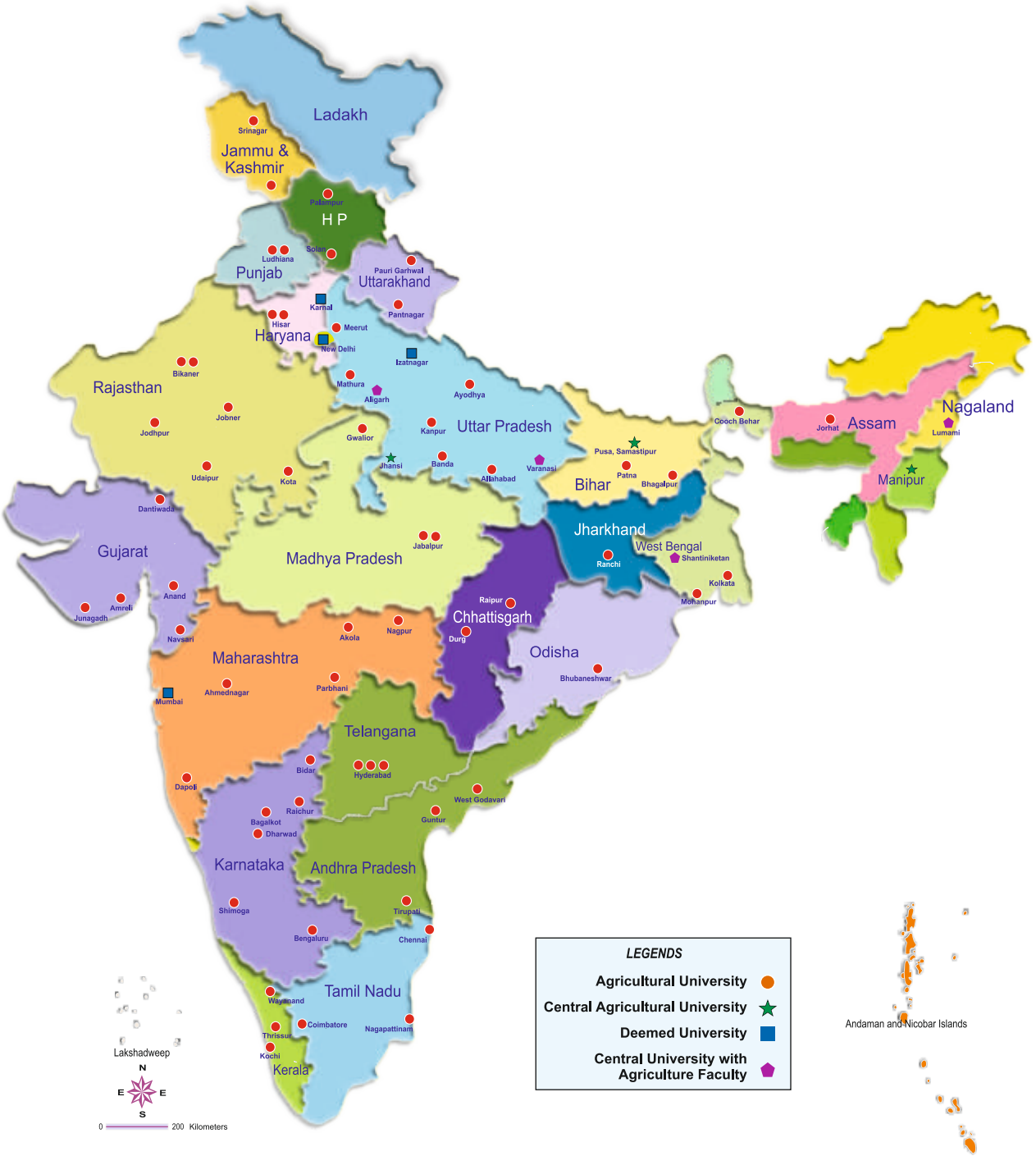
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Agricultural Universities



*Map not to the scale

- 63 State Agricultural Universities (SAUs)
- 3 Central Agricultural Universities
- 4 Deemed Universities
- 4 Central Universities having Faculty of Agriculture

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